NATURE

No. 4360 SATURDAY, MAY 23, 1953 Vol. 171

CONTENTS

	Page
State Support for Scientific Research	895
The Progress of Electronics. By Dr. R. L. Smith-Rose, C.B.E.	897
Economic Plants of the World. By Prof. Ronald Good	898
Science Applied to Food. By Dr. E. B. Hughes	898
Vesalius on the Brain. By Prof. F. J. Cole, F.R.S.	899
Liverpool Meeting of the British Association	901
Standard Samples of Organic Substances for Physico-Chemical Measurements. By D. Ambrose	902
Some Chemical Aspects of Normal Growth. By Prof. F. Bergel	905
Metal Physics Work of the Division of Tribophysics, C.S.I.R.O. By Dr. W. Boas	908
Obituaries:	
Dr. R. W. Gurney. By Prof. N. F. Mott, F.R.S.	910
Dr. C. E. M. Joad	910
Mr. W. Birtwistle	911
News and Views	911
Chemistry and Physics in Spain. By Sir Eric Ridsal, M.B.E., F.R.S.	915
Rumford Bicentennial Symposia and Awards. By Prof. F. E. Simon, C.B.E., F.R.S.	915
The British Dyestuffs Industry	916
Food Products from Plants. By Dr. A. E. Bender	917
British Gelatine and Glue Research Association: Annual Reports for 1951 and 1952	918
World-wide Changes in the Phase of the Cosmic-Ray Solar Daily Variation. By T. Thambyahpillai and Dr. H. Elliot	918
Formation of Labile Phosphate Esters by Irradiation of Nucleic Acids with X-Rays in Aqueous Systems. By Dr. George Scholes and Dr. Joseph Weiss	920
Position of Hems in the Hæmoglobin Molecule. By Prof. D. Keilin, F.R.S.	922
Letters to the Editors:	
Effect of Magnet Inhomogeneities in the Strong-Focusing Synchrotron.—J. B. Adams, Dr. M. G. N. Hine and J. D. Lawson	926
Beta-Spectrum of Arsenic-71.—Hugo Atterling and Sigvard Thulin	927
Creep of Copper under Stress Pulses.—Dr. A. J. Kennedy	927
Microscopical Identification of the Constituents of Coal Dust.—Dr. R. G. H. B. Boddy	928
Alleged Optical Activity in Crystal Class *m*.—Dr. D. Rogers	929
Langmuir Adsorption as a Determinant of Conductivity in a Low-frequency Electric Discharge.—A. P. Saxena, M. G. Bhatawdekar and N. A. Ramaiah	929
Determination of the Relative Electrode Potential of an Uncharged Metal in Solution.—Dr. J. O'M. Bockris and R. Parry-Jones	930
Mechanism of Electropolishing.—Dr. P. R. Rowland	931
Origin of the Methylenedioxy Groups of the Alkaloid Protopine.—M. Sribney and Prof. S. Kirkwood	931
Relative Reactivities of the Olefinic and Cyano Links of Acrylonitrile in the Diels–Alder Reaction.—Prof. G. J. Janz and N. E. Duncan	933
Artefacts produced from 3-Iodo-Tyrosine and 3:5-Di-iodo-Tyrosine by Heating with Alkali.—P. G. Stanley	933
Latent Carcinogenic Action of Beta-Irradiation on Mouse Epidermis.—Dr. Philippe Shubik, A. Robert Goldfarb, A. C. Ritchie and Hermann Lisco	934
Occurrence in Plants infected with Tobacco Mosaic Virus of a Crystallizable Antigen devoid of Ribonucleic Acid.—Prof. R. Jeener and P. Lemoine	935
Effects of Trichloroacetic Acid on the Extension Growth of Root and Shoot Segments of *Pisum sativum*.—Gita Sen and E. K. Woodford	936
A Cladoceran from the Plankton as a Possible Indicator for the Presence of the Nile Flood off the Israeli Coast.—Dr. B. Komarovsky	937
Anaerobic Growth of *Escherichia coli* in the Presence of Certain Acids.—G. A. Morrison	937
Chromosome Numbers in *Holcus mollis*.—A. R. Beddows and Keith Jones	938
Species Formation in *Trifolium subterraneum*.—R. D. Brock	939
Fog Fever Syndrome in Parasitic Bronchitis.—J. F. Michel	940
Transliteration of Cyrillic Script.—M. Aurousseau	940

STATE SUPPORT FOR SCIENTIFIC RESEARCH

THE National Science Foundation was established in the United States in 1950, and is, in some of its functions, the counterpart of the Department of Scientific and Industrial Research in Great Britain. Thus it awards a substantial number of scholarships and graduate fellowships in the sciences, promotes the exchange of scientific information, assesses scientific investigations undertaken by Federal establishments and so on. The allocation of Federal monies for research purposes is in the hands of the National Science Board, consisting of twenty-four persons eminent in science, medicine, engineering, agriculture, education or public affairs; these men, and the executive director of the Board, are appointed by the President of the United States and the appointments are confirmed by the Senate. The first chairman of the Board was Dr. J. B. Conant, now U.S. High Commissioner in Western Germany.

The second annual report of the National Science Foundation*, for the fiscal year 1952, has a foreword by Dr. C. I. Barnard, now chairman of the National Science Board, who insists that the present restriction of appropriations to a maximum of 15 million dollars in any year seriously limits the capacity of the Foundation for carrying out effectively its statutory directives; sufficient funds for the full development of the potential scientific man-power resources of the United States have not been available, and Dr. Barnard maintains that man-power is the critical factor. The proportion of the population potentially capable of assimilating the training required of scientists, or possessing the curiosity, interest and ambition to pursue effective scientific careers, is strictly limited compared with the need for such trained individuals in the development of fundamental science. Moreover, social organization and scientific development have now much reduced earlier limitations on the rate at which practical results could be expected to come from the application of science; and this justifies a greater expenditure of man-power, resources and money solely for the extension of knowledge and development of fundamental scientific ideas for their potential, if not immediately apparent, practical significance.

Dr. Barnard's generalization that we have reached the stage when the maintenance of an expanding pool of tested scientific knowledge is good economics, as well as indispensable in the effective utilization of the world's natural resources for the needs of an increasing and under-nourished population, and essential for military or economic security, is as valid in Great Britain as in the United States; though with the reservation that, in Great Britain, finance and economic resources are perhaps of greater significance than, as in the United States, man-power. Nor would it appear that the significance of fundamental science for our national life, indeed for

* Second Annual Report of the National Science Foundation, Fiscal Year 1952. Pp. viii+77. (Washington, D.C.: Government Printing Office, 1953.) 30 cents.

our international interests, is better understood in Britain than in the United States. Dr. Barnard can find greater encouragement in the support of the scientific community during the Foundation's difficult initial period than could the Advisory Council for Scientific and Industrial Research in its recent report. Neither the Department nor the Foundation can hope to be effective without the active support of scientists and of their institutions.

Dr. Barnard refers also to the danger, inherent in any government organization for promoting basic science, which lies in its propensity to exercise the kind and degree of control appropriate to research and development more closely related to immediate practical ends. That danger is known in Great Britain, and here again the chief safeguard, as he remarks, in addition to the integrity and understanding of the director and members of the Board, is the extensive, active co-operation of scientists in general. Like the Department of Scientific and Industrial Research with its advisory boards and assessors, the Foundation depends for wise judgment of the merits of scientific research proposals upon the personal advice of those most competent and respected in their various fields, and the collaboration of scientists is also indispensable to the Foundation in evaluating scientific progress and scientific needs. This is a task of great delicacy, and in seeking, as required by the Act, to evaluate scientific progress and locate fields that need scientific development, the Foundation must rely upon such collaboration if it is to avoid the dangers of indirect control, too strict adherence to scientific orthodoxy or discouragement of independent research in fields of great potential importance.

Apart from its operational responsibilities for the support of basic research in the sciences, the encouragement of young scientific talent by the award of graduate fellowships, the improvement of science teaching and broadening the flow of scientific information, for which the Foundation has had to devise suitable and effective techniques, the report records definite progress by the Foundation in both the fact-gathering and the analytical phases of policy development. During the year, the Foundation started, as the first of a continuing series of fact-gathering studies under a newly established Programme Analysis Office, to compile statistical information on Federal obligations for research and development at non-profit institutions. Other studies will be concerned with the organization of Federal agencies for research administration and with their budgets for research and development, the content of their research programmes and the impact of Federal support of research upon industrial development and upon colleges and universities in the United States. The Foundation is also supporting an investigation by the American Physiological Society on the content and scope of the physiological sciences, the role of physiology in the realm of education, the professional personnel in the field and the scientific contribution which may be expected of physiology over the next few years and present plans to achieve it.

Besides this, the Foundation has undertaken some short-range studies on scientific topics which are urgent from the point of view of national defence, welfare or scientific promise. The aim in such studies is to determine the extent and kind of Federal support and the outline of basic research needed to make the most rapid progress. Examples cited are the studies of the status, need and potentialities of basic research in high-temperature physics, chemistry and metallurgy, and on the utilization of solar energy from the point of view of both the biological and the physical sciences. The Foundation is also making a full inventory of existing scientific and technical knowledge and research on techniques and instruments for exploration for minerals.

Even this brief summary indicates that, in framing both its short-term and its long-term policy, the National Science Foundation is going far beyond the surveys in 1938 and 1940 of the National Resources Committee and the National Resources Planning Board, respectively, and is covering ground that in Great Britain, at least in part, is dealt with by the Advisory Council on Scientific Policy and by the Select Committee on Estimates, for example, in its report during the session 1946–47 on expenditure on research and development. As the President of the United States emphasized in a message to Congress in January 1952, on the basis of these studies the Foundation will formulate a broad national policy designed to assure that the scope and the quality of basic research in the United States are adequate for national security and technological progress. The Foundation is responsible for a continuing analysis of the whole national effort in basic research, including the evaluation of the research programmes of other Federal agencies.

Although this conception follows the recommendations of the Hoover Commission, it does not appear that support for such a policy is any more firmly assured in the United States than in Britain. The preliminary figures from its survey of the national research effort quoted in this report indicate that the national expenditure on scientific research and development in 1952 was about 3,000 million dollars, of which nearly two-thirds came from the Federal Government, one-third from industry and three per cent from universities. The greater part of this expenditure, and, accordingly, of the available research facilities and specialized man-power, is committed to specific programmes, such as the discovery of new products and cheaper or more efficient processes.

This position is regarded by the Foundation as a serious threat to the security and future well-being of the United States. Great advances in science have seldom come from such applied research, and, in the view of the Foundation and its advisory groups, the corner-stone of national scientific policy is to secure adequate support, in terms of scientific workers and facilities, as well as funds, for basic research in the sciences. The Foundation, moreover, is intended to become, ultimately, the principal agency through which the Federal Government gives support to basic research that is not directly related to the statutory functions of other Federal agencies, and specifically

it is responsible for stimulating or sponsoring basic research in subjects which might otherwise receive insufficient attention. Adequate general support of basic research and training in the sciences constitute, the Foundation remarks in this report, a defence in depth which is essential for the establishment and maintenance of technological supremacy—or perhaps one might better say, excellence.

By the end of 1952 the Foundation was in a position to take the lead in Federal support of basic research, both by considering support of such research in fields receiving inadequate attention and by stimulating or sponsoring such research in scientific subjects of general importance to other Federal agencies. In doing this, however, the Foundation fully recognizes the extent to which success in framing a national science policy depends upon the full co-operation of scientific men in educational institutions, in industry and in the Federal Government service. It claims no monopoly of constructive thinking on these problems; but it is already clear that the Foundation's assertion that it can accelerate the formulation of policy and buttress scientific progress, particularly to meet the unique requirements of the United States, is fully justified. The Foundation points out that, as a country, the United States do not fully appreciate the importance of basic research to technology, tending to reverse the technological sequence—basic research, applied research, development. When all allowance is made for differing conditions in the United States, the experience of the Foundation cannot fail to provide much that is helpful as well as interesting to those responsible for the formulation of scientific policy in Great Britain. The progress of the National Science Foundation and the success of its efforts to correct the lack of balance, especially in times of crisis, between the support of basic research and applied research and development, will be watched and followed with keen interest.

THE PROGRESS OF ELECTRONICS

Advances in Electronics

Edited by L. Marton. Vol. 3; pp. xii+357; 7.50 dollars. Vol. 4; pp. x+344; 7.80 dollars. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1951–52.)

ALTHOUGH there has been a certain amount of resistance to its introduction on the part of physicists and electrical engineers, the term 'electronics' has now become well established as somewhat loosely defining a portion of the field of electrical science. The developments that have taken place in this subject during the past decade or so have been so rapid and extensive that the description of the results achieved occupies a relatively large portion of the scientific and technical literature of the present time. It was with the object of producing a guide to the research worker anxious to acquaint himself with advances in related fields that publication began a few years ago of a series of volumes entitled "Advances in Electronics" under the editorship of Mr. L. Marton, of the National Bureau of Standards, Washington, D.C. The first volume was published in 1949 (see *Nature*, 163, 893; 1949) and was followed a year later by Vol. 2 (*Nature*, 169, 50; 1952).

In the preface to the first volume, an explanation is given of the difficulty which confronted the board of editors in defining the scope of the subject with which they intended to deal. It was decided to limit the scope of their work to the publication of critical and integrated reviews of specific topics in the field of physical electronics and in selected branches of engineering electronics. In connexion with the latter, it was desired to keep to a reasonable minimum discussion of the instrumental and circuit techniques which are associated with electronic devices and which form the subject of a large part of the current technical periodical literature.

In view of the fact that Vol. 3 in the series was published in the first half of 1951, and Vol. 4 late last year, it would seem that it is the ambition or intention of the editorial board to make this an annual series. Furthermore, it is to be noted that, whereas in the first volume all the contributors were drawn from the United States of America, some of the contributions in the two latest volumes are by eminent men of science and engineers in Britain and France.

The first contribution in Vol. 3 is on field-emission microscopy, by F. Ashworth, and this summarizes the experience gained in the investigation of the possibilities of the field-emission microscope, which under suitable conditions may achieve resolving powers of atomic dimensions and magnifications up to a million. The next chapter, on velocity-modulated tubes, brings together the combined experience of four workers in France and California in a review of the theory and mode of operation of the klystron which has proved so useful in the generation and amplification of electrical oscillations at frequencies from a few hundred megacycles per second upwards. There follow two papers on the electronic theory of the plane magnetron, by L. Brillouin, and of the cylindrical magnetron, by L. Brillouin and F. Bloch; these should prove useful to those concerned with the design and development of this type of tube, which seems almost indispensable for the generation of considerable powers at extremely high frequencies. The more practical developments in small electronic components are dealt with in two contributions from the National Bureau of Standards under the titles of tube miniaturization, by J. E. White, and subminiaturization techniques, by G. Shapiro. The last three contributions are more directly related to some of the developments in modern electrical communications, and the ever-present problem of securing an adequate signal as free as possible from any accompanying and disturbing noise. The principles of pulse code modulation are reviewed by H. F. Mayer; modern methods of network synthesis are summarized by E. A. Guillemin; and a timely and useful critical examination of communication theory is presented by M. Leifer and W. F. Schreiber as a conclusion to the volume.

The fourth and most recent volume opens with a theoretical paper on electron scattering in solids, by Prof. H. S. W. Massey, who discusses elastic and inelastic scattering of fast electrons in solids and also multiple scattering and diffusion, and the relative importance of the different processes which determine the electrical resistance of metals, alloys and semiconductors. Next follows a contribution by G. A. Morton on the scintillation counter, one of the most valuable tools in the field of nuclear research for the

detection of high-energy radiations. This discussion indicates the general principles of the phosphor crystal radiation-detector, and its uses and limitations for counter purposes. The article should prove a useful starting-point to those concerned with improving the performance and reliability and the range of applications of the scintillation-counter. The random motion of free electrons in a conductor or the emission of electrons by the cathode of a vacuum tube gives rise to those spontaneous fluctuations of electricity now generally known as 'noise'. In an article on fluctuation phenomena, A. van der Ziel reviews the Fourier analysis of the subject and the application of the phenomena to various generators, including vacuum and gas-discharge tubes, and crystal diodes and transistors. The scope of the subject covered is perhaps indicated by the fact that the list of references at the end of the contribution includes ten books, seven review papers and some ninety original papers. The subject of electronic digital computers is next dealt with by C. V. L. Smith, who reviews the recent development of high-speed automatically sequenced computers. This article includes a description of the machines developed in the United States known as 'Whirlwind', with its special electronic storage tube, and 'SEAC', which at present uses mercury line storage but is so constructed as to permit the later incorporation of cathode-ray-tube storage on the principles developed by F. C. Williams in Great Britain. The magnetron valve again receives attention in this series with a very practical paper entitled modulation of continuous-wave magnetrons, by J. S. Donal, jun. The last two papers in Vol. 4 also strike a more practical and novel note in dealing with, respectively, the magnetic airborne detector, by W. E. Fromm, and multi-channel radio telemetering, by M. G. Pawley and W. E. Triest. The development of both these subjects originated during the Second World War; but it is clear that there are civil applications of the instruments and techniques described, and it is most useful to have these reviews of the progress made during the past decade.

In most cases the contributions in both volumes are accompanied by a selected bibliography which will be valuable in guiding the research student to more detailed knowledge where he desires to seek it. The volumes are very well presented in a uniform style, and there is no doubt that the editor and his advisory board are rendering a great service to the scientific community in presenting this series, which will find an important place on our bookshelves.

R. L. Smith-Rose

ECONOMIC PLANTS OF THE WORLD

Economic Botany

A Textbook of Useful Plants and Plant Products. By Albert F. Hill. (McGraw-Hill Publications in the Botanical Sciences.) Second edition. Pp. xii+560. (London: McGraw-Hill Publishing Co., Ltd., 1952.) 59*s.* 6*d.*

EVERYTHING that helps towards a fuller realization and better understanding of our dependence on the plant world is of value to-day, and the second edition of Dr. A. F. Hill's well-known book will therefore be welcomed not only for itself but also for its considerable contribution towards this end.

The book may be described, like its predecessor, as an invaluable compendium of useful information about useful plants, presented in a way which, though perhaps a little staccato for some tastes, is both direct and simple. In general form it closely repeats the first edition, but it has been brought generally up to date and particularly so with regard to such matters as rubber, antibiotics, artificial fibres, new drugs and so on. A noteworthy addition is a very clear diagram illustrating the modern chemical utilizations of wood.

It is the easiest thing in the world to reproach a book for not being what its author never intended it to be, and Dr. Hill makes it plain that he does not essay to deal with many of the economic and social problems of his subject; but it must nevertheless be admitted that the first pages of the introductory chapter, which is entitled "The Importance and Nature of Plant Products", do something less than justice to the rest of the book. There is a certain bleakness about them, and a slightly more humanistic approach would not only help to illumine the main body of the book, but would also put into truer perspective some of the author's comments on certain agricultural policies and practices. Similarly, in the new preface the emphasis is on plants as strategic materials rather than on their significance as one of the potential ultimate sources of world prosperity and tranquillity. It is this emphasis again, perhaps, that accounts for the rather unexpected order of treatment in the main text, which, beginning with the industrial plant-products such as fibres, wood, rubber and the rest, goes on then to drugs and leaves food supplies until the last. But as regards this book, these are matters of form rather than substance; and although they may involve some difference of opinion, they do not detract from the achievement in Dr. Hill's valuable work. It is a book which claims a rightful place not only in every botanical library but in many others also.

Ronald Good

SCIENCE APPLIED TO FOOD

Food Science

A Symposium on Quality and Preservation of Foods. Edited by Dr. E. C. Bate-Smith and T. N. Morris. Pp. xvii+319+17 plates. (Cambridge: At the University Press, 1952.) 40*s.* net.

TO the scientific worker concerned with the study of food this book is of particular interest and value in that it deals mainly with the chemistry and biology of food materials, with little ordinary technological matter.

The book is, as the editors state, "a collection of lectures by contributors each of whom is an authority in his own field", and is not offered as a comprehensive text-book of food science. It is such study of the fundamentals of food science that is properly the function of the State-owned research stations—and this aspect is a predominant feature in these lectures, which give clearly and concisely a record bringing up to date our scientific knowledge of the subjects discussed. The contributions are written in a simple, logical and direct manner, and the information is given briefly yet with adequate explanation. The style of composition is pleasing and is the same in all

chapters, giving a sense of uniformity throughout the book.

The book is incomplete as a text-book on food science; but it does cover a large and a very important part of the subject. This will be realized from its contents, which consist of a well-balanced and thoughtful introduction followed by successive chapters on economics, supply and distribution of foods in the United Kingdom; the principal foodstuffs—meat, fish, eggs, fresh fruit and vegetables, potatoes and cereals; the basic constituents of foods—proteins, mucopolysaccharides and mucoproteins, carbohydrates and fats; some aspects of quality in foods; the micro-organisms; chemical mechanisms of spoilage; and the principles of food preservation. No chapter of the book gives a full account of the subject discussed—indeed, this would necessitate a book on each—but what is done is to give information and explanation which should advance the intelligent application of science to the study and the industry of food.

Though the standard of information and description is in general a high one which can be properly understood and appreciated only by those who have considerable scientific knowledge and some experience of food science, there are included matters such as data and statements on well-known technical procedures which, though perhaps essentials of the course of lectures, are not so valuable in a book of this standard. This is noticeable especially in Chapter 7 on "The Principles of Food Preservation", which consists largely of such matter, and markedly so in the section on sugar preserves, no doubt because sugars are relatively simple and well-understood constituents of food and because, too, new work in this subject is more associated with their analytical separation and measurement—which matters do not come within the purview of this book. One point of criticism is that the reader may feel, as I certainly did, that in some of the sections there are too many references quoted, many of which seem unnecessary.

E. B. HUGHES

VESALIUS ON THE BRAIN

Vesalius on the Human Brain

Introduction, Translation of Text, Translation of Descriptions of Figures, Notes to the Translations, Figures. By Charles Singer. (Publications of the Wellcome Historical Medical Museum, New Series, No. 4.) Pp. xxvi+152. (London, New York and Toronto: Oxford University Press, 1952.) 21*s.* net.

THE writer of this review is conscious that its title may be perverted into a *double entendre*, and indeed it does recall the following incident. When Harvey Cushing was staying with Osler at his Oxford house, familiarly known as "The Open Arms", a visitor who called to see them was told by Lady Osler that the two Vesalius lunatics were in the Bodleian Library. To these two romantic disciples of Vesalius may now be added a third, in the formidable person of Dr. Charles Singer.

A detailed annotated translation into English or other modern language of the whole of the "Fabrica" of Vesalius is long overdue, although it could not fail to be a profitable enterprise, and its paramount importance to the historian of science is only too evident. The difficulty of the undertaking, however, amply explains the delay. In fact, it seems as if nothing short of a panel of scholars would suffice for the task. Vesalius's Latin is often bewildering, and his meaning may be so obscure as to call for very free and imaginative translation, nor does he always acknowledge his debts to predecessors. Hence the translators must be able to command a knowledge of the history of anatomy as it came down to Vesalius from the time of the Greeks. A few of the figures are also incomprehensible, and even so learned and experienced an interpreter as Dr. Singer is constrained to give them up. Some translation has already been attempted. We have a beautifully printed French version by Verschaffelt of the first six chapters (Haarlem, 1924), English translations of the last chapter and the preface by Farrington (1931–32), German and three Dutch translations of the Epitome (1543, 1569, 1583–86, 1647), English translation by Saunders and O'Malley of Lib. I, Chap. 39 (1946), English translation of the captions of the figures by Saunders and O'Malley (1950), English translation of the Epitome by Lind and Asling (1949), and minor fragments by Lambert and Hotchkiss (1935, 1942). These, however, touch no more than the fringe of the task, and most of them lack the indispensable commentary.

Dr. Singer's translation is based on the first edition of the "Fabrica"; but the second edition has been drawn upon for corrections and additions. These are the only editions for which Vesalius himself was responsible. If we may assume that the high standard of Dr. Singer's edition will be maintained in the complete work, we shall have a modern version of the "Fabrica" of the utmost value, since it could no longer be excusable to consult the illustrations without studying the text.

The present monograph opens with an introduction, in which the author extols the "Fabrica" as one of the great achievements of the human spirit. Its beautiful figures, he says, are Vesalius's most permanent contribution to science, and they establish exact graphic treatment as an essential adjunct of biological research, and as the *causa causans* of the organic sciences. He, however, emphasizes that Vesalius's anatomy is by no means all human. For example, the vascular system is derived from various animals, and may be roughly described as the venous system of ungulates and the arterial system of monkeys. The Introduction includes a brief analysis of the seven books of the "Fabrica", its 'tiresome' Ciceronian literary style, Vesalius as a physiological Galenist, and Vesalius as a discoverer and his debts to his predecessors, especially in regard to his work on the brain. The excellent diagram of Galen's physiological system on p. xix fails to show, what Dr. Singer, of course, knows full well, that the pulmonary artery and precaval vein are afferent and efferent to the heart according to Galen, and that the anterior projection of the "rete mirabile" is the modern chorioid plexus of the lateral ventricle.

The Introduction is followed by the English translation of Chapters 1–12 and 18 of Book 7, which deal with the brain and its dissection, after which come Dr. Singer's instructive notes and comments. Finally all Vesalius's figures of the brain are reproduced and their captions translated, to which are added some pre-Vesalian brain figures by Laurentius (1518), Berengarius (1523), Dryander (1536) and Stephanus (published 1545).

Dr. Singer is to be warmly congratulated on this highly important addition to the Vesalian corpus.

F. J. COLE

The Philosophy of the Enlightenment

By Ernst Cassirer. Translated by Fritz C. A. Koelln and James P. Pettegrove. Pp. xiii+366. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1951.) 40*s*. net.

THIS is a translation of Prof. Ernst Cassirer's "Die Philosophie der Aufklärung" (1932). It is very welcome, and the Princeton University Press has produced a result in keeping with a great theme. The first three chapters give the 'feel' of the Enlightenment, whereas the rest offer more specific information. The appropriate headings comprise religion; the conquest of the historical world; law, State and society; fundamental problems of æsthetics. In all this the reader is confronted by the age of reason, an age bubbling with enthusiasm and seemingly indifferent to the existence of any situation incapable of a purely rational solution. Yet historically it was the heir apparent rather than the heir presumptive (for those having eyes to see) of the Renaissance and the Reformation.

To French clarity of thought, the pedigree must have seemed wholly adequate; to British minds, less shaken by the Reformation, its appeal was perhaps more formative than doctrinal. But in any event, philosophy had come back, true to type, as a way of life, self-liberated from the academic prison. It was to swell over everything, conquering and to conquer. The epoch cannot, however, be described as basically irreligious (as Prof. Cassirer says, undiluted scepticism could never have achieved so much); rather was the tendency one towards transcendentalism, especially in Germany. The paradox of the Enlightenment remains—its rejection of much of the past, coupled with the remarkable stability of a subsequent system founded essentially upon the outcome of a series of severe, and often painful, operations.

F. I. G. Rawlins

Medieval Logic

An Outline of its Development from 1250 to *c*. 1400. By Philotheus Boehner. Pp. xvii+130. (Manchester: Manchester University Press, 1952.) 12*s*. 6*d*. net.

THE author of this valuable historical study modestly claims that he is pointing to a gap in our common knowledge, not filling it; but, in fact, he does a good deal more. His aim is to show two things: that the traditional logic of the text-books, including those of the neo-scholastics, contains no more than part of the medieval logic; and that twentieth-century symbolic logic is a development on the same lines as the part that has been missed out, and in no sense in opposition to medieval ideas as some of its exponents have imagined. It was Kant, not the medievals, who alleged that logic had sprung perfect and fully armed from the brain of Aristotle, as Athena from the head of Zeus. Their view, Father Boehner claims, was that Aristotle had devised the "Ars Vetus" and that they were devising the "Ars Nova", continuing, developing and completing what he had successfully begun. The difficulty for the student of the present day is that so much of the work of the thirteenth and fourteenth centuries is inaccessible; some of it exists only in the form of a single manuscript.

The medieval thinkers developed a theory of 'supposition', of what terms stand for and what substitutions can be made, and also a theory of 'consequences', of the relation 'if—then'. William of Ockham, it appears, used the notion of 'material implication', commonly believed to be the invention of Lord Russell. Most of their ideas go easily and very conveniently into modern notation. Father Boehner makes a useful comment on this point. "Modern logic has made a decided step forward in assuming only a few constants which serve the purpose of bringing about an extremely simplified language. With these constants, their definitions and the rules governing their use, the scholastic theory of supposition has disappeared. It has vanished, however, at the cost of creating a new terminology foreign to that of any ordinary language. Though the language of logic has gained in clarity and precision, it has not been without a price."

A. D. R.

Practical Chemistry for Schools and Intermediate Students

By J. W. Davis. Pp. xxiv+315. (London: John Murray (Publishers), Ltd., 1952.) 15*s*. 6*d*.

THIS book describes more than a sufficient number of chemistry experiments to meet the requirements of the General Certificate of Education of both the Ordinary and Advanced level. Much of the material is off the beaten track, for the author, Mr. J. W. Davis, is known among teachers for his resourcefulness and his novel ideas. Mr. Davis dispenses with chapters and divides his matter into sections, to which he devotes the following number of pages: general chemistry, 71; qualitative analysis, 29; volumetric analysis, 68; preparations (organic and inorganic), 108; and miscellaneous, 33. The last section should be especially interesting to teachers; it contains notes on such matters as the running of a laboratory, the care of apparatus and the uses of various appliances. The full course of volumetric analysis runs mostly on customary lines but includes a few novelties. The scheme of qualitative analysis, framed for mixtures containing one metal per group, exhibits no unusual features. It is in the preparations and in the many informative experiments illustrative of fundamental principles that one meets the author's skill and originality. Herein Mr. Davis displays a rare aptitude for modifying classical experiments and familiar techniques and devising new ones with economy of time and apparatus. His book can be confidently recommended.

Joy and Verity, other Poems and a Poetic Drama

By Dr. Marie C. Stopes. Pp. 126. (London: Hogarth Press, 1952.) 6*s*. net.

THIS is the latest volume of a series of poetical works by Dr. Marie Stopes that began to appear in 1939. They are interesting in that love is treated passionately from a feminine point of view, and that the author does not hesitate to touch the themes of science with emotion and with imagination.

The outstanding poem in the volume is the title poem of forty-one stanzas, "Joy and Verity", which contains the distillation of a whole philosophy of life.

Personally, I enjoyed the poetic drama "Antigone Awakened". The matter is interesting—the theme of Sophocles' play with another ending. The spoken words of the actors and the chorus run easily and leave a feeling of freshness and of music.

Dr. Marie Stopes has always been a crusader. One gets more than a hint that the reforming spirit is now turning its attention to the breaking down of the inhibitions of scientists.

F. K.

LIVERPOOL MEETING OF THE BRITISH ASSOCIATION

THIS year the British Association will meet in Liverpool for the sixth time. Between the first occasion in 1837 and the last in 1923, the alteration in the character of the meetings has reflected the change in the status and the role of the scientist no less than its proceedings have recorded the progress of a revolutionary age. In 1837, the president was William Cavendish, Earl of Burlington; but the address was read by Prof. Traill. Few records of the meeting survive beyond the girdings of the critics at what was thought to be the excessive degree of feasting and festivity. In 1854 the president was again a man of affairs, the Earl of Harrowby, and his address, carefully composed and resounding in phrase, was in part the conventional record of the Association's work during the year and in part an expression of his own views on the place of science in the community.

The later meetings, in 1870, 1896 and 1923, brought men of quite different outlook and reputation to the presidential chair. The first was T. H. Huxley, who delivered a remarkable address on the history of the rise and progress of a single biological doctrine which he termed biogenesis. In 1896 Lister spoke on Röntgen rays, on Pasteur's work on fermentation and then, for the first time before a public audience, about his own contribution to antisepsis. It is interesting to recall that Rutherford, who was president at the Liverpool meeting of 1923, attended his first meeting of the Association in 1896. It was natural that he should refer to it in the address which he delivered in 1923. "The visit to your city in 1896 was for me a memorable occasion, for it was here that I first attended a meeting of this Association, and here I read my first scientific paper. . . . The year 1896 has always seemed to me a memorable one for other reasons for in looking back with some sense of perspective we cannot fail to recognise that the last Liverpool meeting marked the beginning of what has been aptly termed the heroic age of Physical Science." It was peculiarly appropriate that Rutherford's presidential address should have been the first to be broadcast. It was a bold experiment on the part of the B.B.C., in the cultural no less than in the technical sense, and even in those days when cumbersome headphones had to be used and the crystal detector delicately adjusted, it seems to have been justified by its success. It was appropriate for another reason that the first such broadcast should be made from Liverpool, because the earliest public demonstration of signalling for short distances by electric waves had been given at the Association's meeting at Oxford in 1894 by Oliver Lodge, who was at that time professor of physics at University College, Liverpool.

Sir Edward Appleton will deliver his presidential address this year on "Science for its own Sake". In addition, Sir Edward will deliver a junior presidential address to student members, the title of which will be "Finding Things out with Radio and Rockets". This event will be an innovation, the idea of which came from the president himself. As at the Belfast meeting, special provision will be made for young people. Indeed, it is hoped that the active participation of young people on a larger scale than ever before will be a feature of the meeting. The local education authorities of Merseyside have expressed a lively interest in the project; and, with their co-operation, it is confidently expected that there will be a thousand student members at the meeting.

The handbook, "A Scientific Survey of Merseyside", has been prepared under the editorship of Prof. Wilfred Smith, and the majority of the articles have been written by his colleagues in the University. Those who know the care and time which have been given to the preparation of the handbook are confident that it will be an authoritative presentation which will merit a permanent place on the bookshelf as a work of reference.

The evening discourses will be given by Sir Harold Spencer Jones on "Continuous Creation" and by Mr. Eric Shipton on "Everest". The presidential addresses in the sections range from "The Development of Organic Chemistry since the Time of Liebig" by Prof. G. R. Clemo, to "Open and Repressed Monetary Inflation" by Prof. F. W. Paish. Not the least attractive should be the address in Section L by Mr. Robert Birley, headmaster of Eton College, under the provocative title, "Greek or Chemistry or Both ?".

The programme of general excursions is varied; they will range as far as Lake Vyrnwy in one direction and Lake Windermere in the other. Some of the sectional visits of more technical interest will be to the developing chain of light industries on either side of the Mersey. Further, after the meeting ends, there will be a special visit to the Isle of Man during September 9–12 at the invitation of the trustees of the Manx Museum.

There is no doubt of the welcome that Liverpool will give to the Association. The city values its long connexion with the British Association and the forthcoming meeting is anticipated with eagerness. The Norman Lockyer Lecture which was delivered by Sir Harold Spencer Jones in January was immensely successful. The Philharmonic Hall was filled and could have been filled again.

The University is especially proud to receive the Association in its own jubilee year, the celebration of which has just ended. Since the last meeting in Liverpool the accommodation of the University, for the smaller meetings, has been considerably extended, and the sections will have ample space within the precinct for most of their activities. The inaugural meeting will be held on September 2 in the splendid Philharmonic Hall belonging to the City, and will be preceded by a special congregation of the University for the conferment of honorary degrees.

The local committee for the meeting is confident that, under the presidency of Sir Edward Appleton, it will be an outstanding success; for it will bear the impress of its president's rare qualities of intellect and character.

STANDARD SAMPLES OF ORGANIC SUBSTANCES FOR PHYSICO-CHEMICAL MEASUREMENTS

By D. AMBROSE

Chemical Research Laboratory, Teddington, Middlesex

FORMULATION of the fundamental laws of chemistry depended upon the recognition that properties of pure substances are constants which can be measured, and improvements in technique have required ever higher standards of purity in the samples used for these measurements, since the values obtained are frequently sensitive to the presence of small amounts of impurities; the use of impure samples is, in fact, one of the chief reasons for distrusting many of the older physical data acquired when chemists were building up the vast body of chemical knowledge, and in recent years a start has been made in accumulating a corresponding body of exact physical knowledge about pure chemical substances. To illustrate the need for this, melting and boiling points, the properties most frequently recorded to characterize substances, may be considered. A pioneer in the study of pure compounds has been Prof. J. Timmermans (of the International Bureau of Physico-Chemical Standards, Brussels), who in his books "Chemical Species" (1941) and "Physico-Chemical Constants of Pure Organic Compounds" (1950) has laid down the principles to be followed in a critical appraisal of published data, and collated what is satisfactory. Of the thousands of organic substances known, data for only about fifteen hundred are included in the publication last mentioned, and whereas the author states that boiling points should be known to 0·05° C. and freezing points to 0·1° C., in few cases is the range of values quoted from different investigators as small as this, even for common substances; for example, there is a range of 0·9° C. for the freezing point of methyl alcohol and 0·6° C. for the boiling point of acetic acid.

Precision is of value not only in fundamental science but also in applied science and industry, and a striking characteristic of modern chemical industry is the increasing stringency of specifications even for technical grades of material. Besides the economic reason that unwanted impurities are paid for as the desired material, pure materials tend to give purer products with greater reproducibility of properties and there is a necessity for purity (or at least a constant composition) in pharmaceutical products where traces of impurity may have great physiological effect. Some years ago, benzene of freezing point 5·4° C. was considered a first-grade material and anything with a higher melting point was almost unknown; but the true freezing point has been established as 5·53° C., and there is now a demand for commercial quantities of material approaching this purity for synthetic processes; a similar situation is arising with naphthalene, for which the present standard test is based on a melting point of 80·2° C., whereas the best value is now 80·27° C., corresponding to a change in the purity as determined by melting point of approximately 0·2 per cent.

This rise in the standard of commercial materials is due to the development of improved methods of analysis and process control which enable specifications to be drawn up and material to be produced nearer to the exact requirements of the user; and satisfactory analytical techniques depend upon the availability of pure reference samples. Such standard samples of inorganic materials have been available for many years; for example, the U.S. National Bureau of Standards has supplied standard alloys and pure metals for the past fifty years, and the system of standard analytical reagents is well established; but the use of organic standards is a recent development with which this article will deal.

Use of Standard Samples

The uses of standard samples may be broadly divided into two categories. In the first (the primary establishment of standards) fall the determination with the highest attainable accuracy of physical properties of substances, and following those determinations, the intercomparison of measurements made in different laboratories and the transfer of measured quantities from one laboratory to another. For such purposes the user has generally had to purify and standardize the substance himself by applying suitable tests; but in the past ten years a remarkable example of co-operative work has been carried out by the American Petroleum Institute in conjunction with the U.S. National Bureau of Standards in preparing more than two hundred hydrocarbons in a state of the highest attainable purity for the systematic measurement of physical properties at various laboratories. To workers engaged in the field of pure organic compounds, this American contribution, which has been under the direction of Prof. F. D. Rossini, overshadows all others; but consideration that, even so, only about twenty compounds a year are being examined, shows what a stupendous task the collection of physico-chemical data is, and only those restricted fields of chemistry can be examined in which they are most needed.

The second category of uses for standard substances includes those in which the values of their properties as determined with the highest grade of instrument are used to calibrate and check the readings obtained with other instruments. Perhaps the most familiar example of this is the calibration of thermometers at the ice- and steam-points, and water is probably the most widely used standard substance, its triple point, latent heat of fusion, specific heat, and density being used as standards; other examples of the use of standard substances are provided by mercury for measurement of pressure, benzoic acid for calibrating bomb calorimeters and the whole series of secondary fixed points in thermometry. Besides direct calibration, it is useful to be able to check the results of a given method (and the operator) by applying it to a pure material the value for which is known accurately. A typical example occurred in the Chemical Research Laboratory, Teddington, when measurements of the refractive indices of a number of pyridine bases were unaccountably discordant. It was not until samples of pure *n*-pentane were also examined that the cell of the Pulfrich-type refractometer was found to be unsuitable for use with volatile liquids; when the cell had been modified, no further difficulties were experienced. The necessity for this would have been much harder to demonstrate had samples of materials known to be pure not been available.

Fresh interest in the use of standard substances, especially hydrocarbons, has been aroused by the

widespread adoption of instrumental methods of analysis; in particular, the infra-red, ultra-violet and mass-spectrometers, the last of which has become a standard method of analysis for hydrocarbon gases in the still rapidly expanding petroleum and petrochemical industries. In general, analysis with these instruments is carried out by consideration of the pattern produced over a wide range of wave-length or mass number, and to this end a large number of spectrograms and cracking patterns of pure materials have been published, chiefly by the U.S. National Bureau of Standards, which do, in fact, enable analyses to be made. It is, however, more satisfactory to check the instrument-reading on a standard sample as well, since different instruments have their own characteristics, causing slight variations in the pattern produced. So marked is this with the mass-spectrometer that frequent recalibration with both pure materials and blends of known composition is needed, since the cracking pattern changes according to the condition of the electrodes. For these purposes it is impracticable for the user to make all the standards he needs, and in any event the use of standards of one origin eliminates a possible source of error when results obtained in different laboratories are to be compared. Requirements for standard samples are therefore still increasing, and in view of their importance the Commission for Physico-chemical Constants of the International Union of Chemistry has decided that one of its aims shall be the encouragement of their use.

Purification

Generally, the preliminary stages in the preparation of material suitable for use as a standard must be carried out on a relatively large scale to permit the discard later of considerable portions containing impurities; and where possible it is often preferable to start with a commercial grade of the substance, or one closely related, which may be intensively purified to yield a small proportion of high-grade material, rather than to attempt a complete laboratory synthesis. This is the method used for the simpler coal tar and petroleum products such as benzene, toluene and the lower aliphatic hydrocarbons; but suitable raw material is often not available for more complicated substances. Laboratory methods of synthesis have then to be applied, often on an unusually large scale since it is desirable to make batches of about 1 kgm. and, for example, methods have now been developed for carrying out the Grignard reactions necessary in hydrocarbon syntheses on a 50-mole scale. In synthesis it is important that all materials used should be purified to avoid unnecessary impurities arising in the reaction, and further purification should be carried out at each of the intermediate stages even if the yield is thereby much reduced. The methods of purification are the usual ones of the organic chemist—distillation, crystallization, sublimation, adsorption, besides any suitable chemical reactions—but carried to the limit with consequent reduction of yield. In ordinary synthesis a balance has to be struck between the requirements for purity and for high yield; the second cannot be considered in producing material of the highest purity and, for example, in the production of 99·99 per cent benzene the material was crystallized about twenty-five times, while in distillation processes to produce the API-Research samples, often a middle cut of only 200–300 ml. was taken from 1 or 2 litres of already highly purified material.

Purity: its Definition and Determination

A pure substance may be considered as one all the molecules of which are identical, and it is customary to express purity in moles per cent, or the fraction of identical molecules in a given sample; but a difficulty arises over the definition of identical molecules because of the existence of isotopes. These cause definite variations in properties, but so minute that separation is rendered exceedingly difficult; not so minute, however, but that the exhaustive fractionation applied in purifying a sample may change the isotopic abundance ratios sufficiently to cause a measurable change in properties. Not only do the isotopic ratios change in the laboratory, but also their slight differences in thermodynamic and kinetic properties have led to natural fractionation so that the natural isotopic ratios are seldom constants. The Pure Metals Commission of the International Union of Pure and Applied Chemistry has resolved this difficulty by adopting two definitions of a pure metal, an 'ideal', and a 'practical'. A practical definition can only be considered in terms of the use to which the purified material is to be put, and the measurement by which the purity is determined. Any absolute definition which might specify the isotopic abundance ratios given by the International Commission of Atomic Weights would be ideal because they are not controllable in highly purified materials, and this applies throughout chemistry.

In setting up a chemical standard, the effect of the residual impurities must be considered; if negligible on the property to be measured, then those impurities may be ignored even though purity determined by other measurements is low. Of course, it will usually happen that a highly purified material will be suitable as a standard for many properties; but this is not always so, and sometimes the requirements for different properties are considerably different or even mutually exclusive. Hence the practical definition of a pure material as one the properties of which are unchanged by further purification must be qualified by a list of those properties, and each material considered separately before the statement of purity is generalized as indicating a standard for all properties. For example, the term 'spectroscopically pure' is used for solvents suitable for spectroscopy, but this merely means that the *cyclo*hexane or *iso*-octane frequently used in ultra-violet work is free from impurities which absorb in that region, that is, olefines and aromatics, and they almost certainly contain other naphthenes and paraffins which do not affect their properties in the ultra-violet. Again, the lower pyridine bases all have refractive indices between 1·50 and 1·51, so in a sample of one of the picolines the effect on refractive index of a small proportion of another isomer is negligible compared with the similar proportion of water ($n = 1·33$) which is absorbed on manipulation in air. On the other hand, in standardizing an instrument for the infra-red analysis of mixtures of these substances, it is the isomeric impurity which is of importance since the effect of water is easily allowed for.

Thanks to its special properties at low temperatures, the production of helium containing only 10^{-10} impurity has been claimed; but this is unique, and the present limit of impurity removal from organic compounds is usually about 10^{-4}, a figure which is outside the sensitivity of most chemical methods of analysis applicable to organic materials, for the impurities present are often either homologues or

isomers with almost identical chemical properties. Purity determination of organic compounds then depends upon physical measurements, and these should remain unvarying through whatever further process of purification the material is put, or from whatever source it is obtained, whether natural or synthetic. Any suitable physical property may be used, such as density, refractive index, boiling point or vapour pressure, that one being chosen for which so far as possible the substance has a value clearly distinct from its possible contaminants. Spectrometry is usually only a subsidiary method of checking pure compounds, since although sharply defined characteristics of the spectrograms sometimes enable certain impurities to be detected in trace quantities, there are often others present in considerable concentration which cannot be detected. Thus it is usually desirable to combine the results of several methods of testing. During the past ten years, however, methods of freezing-point determination have been developed which enable a quantitative estimate of purity to be made, and this precision and the relative simplicity of the determination have led to their widespread adoption in place of other methods; in fact, it is through this development that the supply of standardized materials has been put on a satisfactory basis. Melting-point determinations have long been used by the organic chemist as a check on purity, the assumption that all impurities lower the melting point being generally valid; but as customarily carried out, they are not precise, and freezing points are now much more accurately determined by plotting cooling curves. A sample of the liquid material is allowed to cool at a controlled rate in a suitable apparatus and its temperature measured precisely, in early methods with a platinum resistance thermometer but now more generally by some kind of automatic recording device, since it is not the absolute temperature but the change in temperature which is of importance. Most liquids must supercool before crystallization will occur, and skill is required to reduce the extent of supercooling to the minimum, by seeding at the right time, so as to produce as smooth a curve as possible. The rate of cooling is made very slow (perhaps 1° in 10 min. before crystallization begins), so that the complete cooling curve may take up to 1½ hr. to plot, and thermal equilibrium between solid and liquid is attained by stirring. In these conditions, when changes in temperature are measured to 0·001° C., a gradual depression is normally found as solidification takes place, from which the purity of the sample can be calculated, the limit of detectable impurity being about 0·01 mol. per cent. It may sometimes be preferable to work in reverse and plot a melting curve, for example, with substances which form glasses under conditions of slow cooling; the validity of the method depends upon the assumption that the pure material crystallizes from the melt, and where this is in doubt more complicated measurements of the specific heat in the melting region are required. These provide an even more sensitive test for impurities, but fortunately there is a large range of substances for which melting- or freezing-point determinations are adequate.

The value of freezing-point determinations is leading to their gradual adoption for routine testing besides the establishment of standards; but in ordinary practice purity is often established by comparing the properties of samples with a standard or the equivalent, the published values. This is actually a way of establishing impurity, but if a number of properties are of the correct value the purity may be considered as satisfactorily established.

Supply of Standard Samples

The scale and type of work required for the preparation of pure compounds and measurement of their properties has resulted in a small number of laboratories specializing in it, of which the leading one has been the U.S. National Bureau of Standards in Washington. In conjunction with the American Petroleum Institute, about two hundred compounds, mostly hydrocarbons, are supplied in certified purity for use in calibrating spectrometers, and in addition the best samples are available on loan as the API-Research samples to investigators who wish to measure needed physical properties. Purities of these last normally lie between 99·7 and 99·95 mol. per cent, and those of the spectroscopic standard samples only a little lower. (This work has now been transferred to the Carnegie Institute of Technology, American Petroleum Institute Research Laboratory, Pittsburgh 13, Pennsylvania, U.S.A.) Certain hydrocarbons of slightly lower but still high and certified purity are also sold commercially in the United States, and when in 1949, in Great Britain, the Chemical Research Laboratory was asked by the Spectroscopic Panel of the Institute of Petroleum to start a scheme for the supply of standard samples of hydrocarbons, stocks of some of these were obtained for division into small samples, and some from the National Bureau of Standards. This scheme accorded well with the existing programme of the Purification and Measurements Section of the Organic Group of the Laboratory, which was already engaged on the purification of coal tar constituents with the view of measuring the following properties: vapour pressures, melting points, densities, refractive indices, ultraviolet and infra-red spectra, and, in conjunction with the National Physical Laboratory, heats of combustion and specific heats over a wide range of temperature; and the Laboratory now has a list of more than three dozen standard substances available for distribution, of which nearly one-half, including four coal-tar bases and five aromatic hydrocarbons, have been made in Britain. Various industrial firms have co-operated in the preparation of standards by providing suitable stock for purification, and one industrial research laboratory has given material of a purity sufficiently high for use as a standard; such gifts are welcome to augment the restricted resources available to the scheme, and acknowledgment of the source of the materials is made when samples are distributed. In selecting further compounds for inclusion in the standard samples programme, due regard is paid to the direction of the research programme approved by the Chemistry Research Board, and the needs, so far as we can ascertain them, of our customers; for the scheme to be of the greatest service it is essential that the Laboratory should aim at making those standards for which there is the widest demand. In the three years during which the scheme has been in existence, approximately eight hundred samples have been supplied to nearly forty different laboratories in industry and the universities.

This article, describing the background to one aspect of the work of the Chemical Research Laboratory, Department of Scientific and Industrial Research, Teddington, is published by permission of the Director.

SOME CHEMICAL ASPECTS OF NORMAL GROWTH*

By PROF. F. BERGEL

Chester Beatty Research Institute, Royal Cancer Hospital, London, S.W.3

IN his book "On Growth and Form"[1], where he describes the application of mathematical-physical methods to these two facets of biology, D'Arcy Thompson said that growth was a somewhat vague word for a very complex matter. Stimulated by this remark, a definition of growth and related phenomena was sought. After enumerating examples of mechanical and non-biological growth[2], including that of crystals[3] (illustrated by ciné films[4]), certain basic characteristics emerged, such as dependency on time, interdependency of growth, development and form, and irreversibility of increase in mass or volume. Then attention was turned to the cell as the unit of living matter. There biological growth consists of two kinds: by enlargement—auxetic growth; and by division—multiplicative growth. Further events may take place which are so closely connected with biological growth that they were by necessity included: fertilization, induction and differentiation, maintenance, regeneration and repair. Considering them in the light of elementary cytological knowledge, the following definition of biological growth phenomena was established: they are processes consisting of continuous synthesis of complex cellular constituents from assimilated material, leading through cell enlargement and multiplication to the mature organism, the size of which is determined by certain limiting factors and which often, by production of egg-cells undergoing fertilization by sperms, can perpetuate itself.

The next step was to seek out those problems which have yielded or would yield to a chemical or physico-chemical treatment. Obviously energy is required to enable the cell not only to grow and to synthesize its constituents but also to maintain its high degree of orderliness. This energy is provided by light quanta in plants and by oxidation–reduction metabolism in animals. As randomness or disorder from a thermodynamic point of view corresponds to high entropy, and the opposite to low entropy, the carbohydrate and phosphate cycles, coupled to protein and fat metabolism and assisted by innumerable enzymes, generate energy in such form and manner that the remarkable stability of cells and their specific and identical processes—that is, a low state of entropy—are maintained.

Apart from oxygen and water, nutrients reach the cell and penetrate through the lipoproteinous membrane; on the whole, small molecules are taken up with greater ease and are then caught inside the cell by microsomes, mitochondria and the nuclei with their pre-existing large molecules, to be transformed into compounds required by the cell. It is assumed that the identity of specific sequential and steric properties of macromolecules so produced may be due to moulding processes on template molecules.

In contrast to some bacteria and fungi, the growth of which on synthetic media has been studied profitably, amœbæ do not grow on such media, and the development of tissue culture towards the use of synthetic nutrients, as investigated by Dr. C. Waymouth at the Chester Beatty Research Institute, is only slowly progressing. Although one knows at present relatively much about the metabolic events of energy production and the constitution of small molecular cell-constituents, it has taken a long time to sort out these low-molecular essentials with regard to their effect on growth, and it may take very much longer to recognize the possible existence and role of larger particles. The biochemical problems of cell division are not solved yet in detail. Whether the attainment of a critical ratio of size between cytoplasm and nucleus or between surface and volume, or whether with the enlargement of the cell the critical concentration of substances possibly of nucleic acid nature[5] will trigger off mitosis, or whether a number of factors have to come together to this end, the last and true physical or chemical cause of cell cleavage is still largely unknown. Even greater complexities meet the student of the biochemical phenomena of fertilization, induction and cyto- and histo-differentiation. Shifting of nucleic acid gradients[6], mutual influences of the first cells derived from the fertilized egg[7], polarities in the cells and defined evocator substances[8] have been suggested, defended and sometimes abandoned. Particularly, the story of the evocators is in some respects reminiscent of that of the carcinogenic substances, because in both groups a great number of dissimilar substances, maybe by different modes of action, produce the same terminal effects—morphogenesis and malignancy, respectively. Claims have been put forward in favour of embryonic growth factors being replaceable by proteose–polynucleotide combinations[9]. It is not impossible that the disappearance of such specific factors, together with the cessation of sensitivity of most tissues to the action of growth regulators of low molecular weight, may contribute to the slowing-down and final arrest of growth in the adult organism. In addition, mechanical and thermodynamic conditions could lead as well to this phenomenon of limitation of growth, especially if energy required for maintenance and repair reaches equality with that produced by metabolic processes and thus, roughly speaking, loss of heat can be just balanced by intake of food.

Building Units

It is recognized that, apart from medium-sized and smaller units such as co-enzymes, some hormones, energy carriers and other functional substances, mostly large molecules, are present in cells and participate in their structure, growth and development. On the other hand, still larger particles such as microsomes, mitochondria, chromosomes, nuclei and plasmagenes form the subject of recent investigations which will not be included in this review. Among the macromolecules, proteins and nucleotides seem to play a major part in cellular events. Dr. T. S. Work[10] has, in some recent lectures, described the biosynthesis of proteins. It remains, therefore, to consider the nucleic acid problem and to give some attention to configurational questions with regard to proteins and to the relationship between the synthesis of these two macro-structures so that some of the points touched upon above may become clearer. In Table I the connexions between pyrimidines, purines, nucleosides, nucleotides, and finally ribo- (RNA) and deoxyribo- (DNA) nucleic acids are presented. The biosynthesis of the bases and the sugars have been progressively studied during recent years[11]. The

* Synopsis of three lectures given at the Pharmacology Department, University College, London, during January–February 1953.

work of the Cambridge school has largely contributed to the final elucidation of nucleosides[12] and, together with the results obtained by American workers, to that of the nucleic acids themselves as poly-3′ : 5′-phosphates.

The most stimulating analysis by Brown and Todd[13] of accumulated evidence with the important hypothesis of 2′ : 3′-*cyclo*phosphates as intermediates of breakdown of ribonucleic acid has led to the isolation by Markham and Smith[14] of such compounds from controlled hydrolysis of ribonucleic acid. Table 1 also traces the interconnexions of nucleic catabolism which, so it is believed, following work by Haddow and Timmis[15] on substances producing kidney hypertrophy, is as important for normal growth as their anabolism or synthesis. A study of the enzyme systems responsible for the last stage of the degradation, particularly of xanthine oxidase and its inhibitors, has been commenced in this connexion[16].

From the configurational and physico-chemical point of view, especially according to recent work by Butler *et al.*, Ambrose, and Alexander *et al.*[17], one is more inclined to favour the Furberg variation of Astbury's closely packed column of deoxyribonucleic acid with its bases alternating on both sides of a zig-zag phosphate-sugar chain. This arrangement produces a practical distance of about 7 A. between the acid groups of the polyelectrolyte if the macromolecule is moderately stretched. How this fits in with the newest rope idea of Pauling and Corey[18] for nucleic acid will have to be seen, particularly as nucleic acids *in vitro* and *in vivo* may show differences in steric properties. However, the recent views on structure and physico-chemical properties of proteins[19,20] would fit in well with nucleic acids having, apart from branching, only a statistical but not a factual distance of 3·4 A. between neighbouring acidic groups like the proteins in β-*trans*-configuration between proximate side-chains. There are some steric questions in the protein field to which there exist more than one answer. Proteins can also occur in a contracted α-form, and Pauling and Corey[19] have suggested for this an α-helix arrangement with side-chains at right angles to the axis of the spiral and hydrogen bonding across turns. More recently these American authors[21] expressed themselves in favour of a polypeptide chain helix itself pursuing a helical course ; several of these would form rope-like strands similar to those mentioned above for nucleic acids. As nearly all functional proteins belong to the group of globular proteins, it is important to know something about their history of formation. According to Ambrose[22], they originate in a kind of β-α-pathway (to which reference will be made below) to coil up either as a result of interaction of reactive side-chains or, following Pauling's antigen–antibody hypothesis, around or below another protein molecule of a certain shape. As far as their primary synthesis in β or α form is concerned, this brings one face to face with the problem of identical reproduction of configurational and sequential features of proteins in the cell. Gale's recent work[23] on *Staphylococcus aureus* and the selective inhibitory action of certain antibiotics on the protein and nucleic acid synthesis of these bacteria supports the views expressed before in various quarters that nucleic acid and protein syntheses are interconnected. So far it has not been established in what manner. *In vivo* polynucleotides are always combined with proteinous substances such as histones, protamines or proteins. If one takes into consideration what was said above, namely, that *in vitro* observations may not apply to the conditions in the cell, the speculation that nucleic acids act as templates, or at least as part of templates for their own synthesis and that of proteins, is an attractive one ; but no final proof is as yet available. Recently, Dounce[24] has published some ideas on this subject, the first step of the biosynthesis consisting of an

Table 1

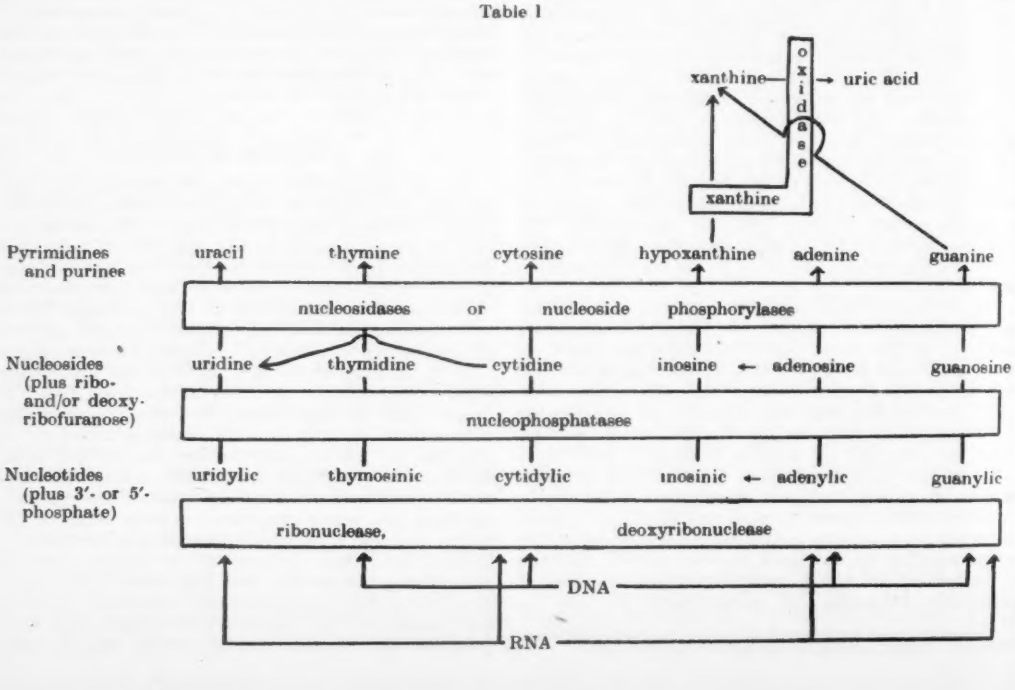
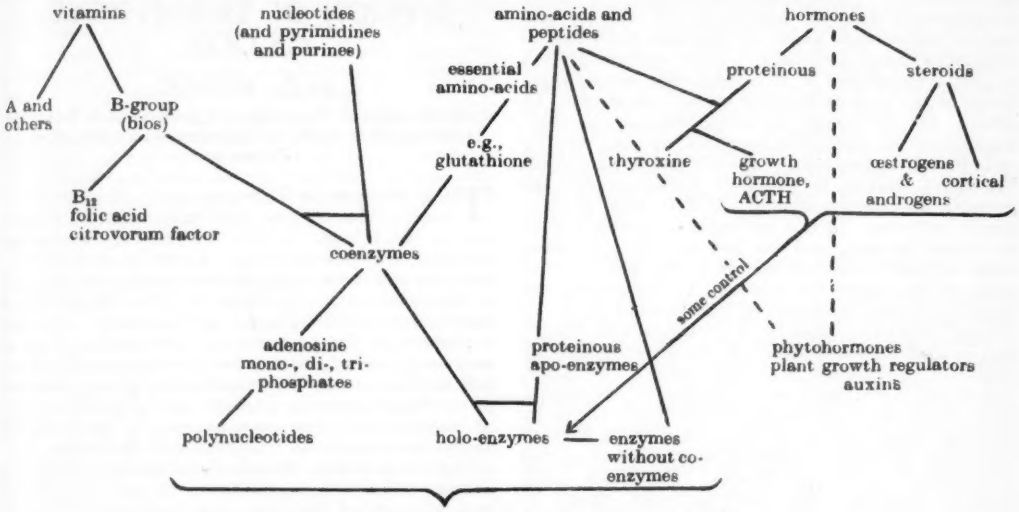


Table 2



action of adenosine triphosphate on nucleic acid, producing a hypothetical diphosphonucleic acid from which, with amino-acids, polypeptide-chains and with mono-nucleotides, polynucleotides are supposed to emerge. If one pays more attention to experimental evidence and takes into consideration the following points—the 7 A. distance of the side-chains in the β-*trans* form of the initial peptide chain and of the P—OH-groups in the Furberg nucleic acid model, the relative lack of specificity of nucleic acids in directing the sequence of amino-acids, and a hypothesis put forward by Haurowitz[25]—one can arrive at another speculation. It amounts to this: that a pre-existing protein is held in position by the nucleic acid which is acting mainly as a 'backbone', and that the protein functions as the actual template on to which amino-acids 'crystallize' out each on identical spots in a crystal growth fashion. Possibly under the influence of further enzymatically acting proteins, a peptide chain is formed. This new peptide chain will leave the surface of the template and overcome its attracting forces if, after Ambrose[22], one assumes that the intramolecular attraction of N—H and C=O groups to form hydrogen bonds could pull the amino-acid side-chain away from the template. Now, the new protein folds up into a globular form as indicated above. There are, of course, other views, such as that expressed by Work[10] on transpeptidation. It is clear that all this needs more solid experimental evidence in the future.

Regulators

It was mentioned before that smaller molecules play their part in cellular events, and some exert considerable influence on growth phenomena. These can be loosely grouped together under the name of growth regulators, a term which, even when restricted to those substances occurring in living organisms, still comprises substances of great chemical diversity. From Table 2 it can be seen that a variety of sub-groups is involved.

Some of these substances are synthesized by the organism; others are ingested with food. Some are involved in energy-producing metabolism; others have specific anabolic or catabolic functions or form the right building-units for the synthetic processes of the cells. A considerable number have similar or identical functions in lower and higher organisms due to the same biochemical arrangements. However, the auxins or plant growth regulators seem to exercise their promoting and controlling effects solely in higher plants—for example, the group derived metabolically from tryptophane, indolylacetic acid and indolyl acetonitrile[26]. The mode of action of these and a great number of synthetic analogues has not so far been established with certainty, although attempts at solving the mystery of their stimulatory and inhibitory effects have been made[27]. Such attempts have promoted work in the field of abnormal growth, for example, that on urethane by Haddow and Sexton[28]. It is especially the B-group of vitamins which have proved to be of equal value to micro-organisms and animals, a matter which has been recently discussed, among other things, on the occasion of a meeting of the Nutrition Society[29].

Apart from those identified with bios factors, and with essential co-enzymes, a super-growth factor *T* was claimed by Goetsch[30] to have been isolated from torula yeast. Later[31], it was shown that it consisted of a mixture of folic acid, folinic acid, *Lactobacillus bulgaricus* factor, deoxyribosides and a small amount of vitamin B_{12}. The last-named and folic acid and its derivatives have aroused particular interest, as they may be involved in nucleic acid synthesis and thus in cell division[32]. While it is not clear whether they participate in these events in the form of co-enzymes, the situation with pantothenic acid is now clarified. The formula of co-enzyme A has recently been published[33], and its role in biosyntheses, such as those of citrate, fatty acids, sterols and phospholipids, established. Even a peptide, glutathione, has now been recognized as a co-enzyme by Racker and

Krimsky[34]; it is involved in the oxidative phosphorylation of phosphoglyceraldehyde. Whether strepogenine, another peptide-growth factor, and certain amino-acids which in tadpoles, according to Gudernatsch and Hoffmann[35], either support growth or just maintenance or morphogenesis, act as regulators or are used as building units, is unknown. Of course, all functional proteins, whether as apoenzymes or as proteinous enzymes, operate directly or indirectly in processes of growth and development. The same applies to pituitary hormones such as growth, adrenocorticotropic (ACTH) and gonadotropic hormones, the first having an immediate effect on overall growth, and the last two by controlling other endocrine substances. It is not unlikely that some of the effects are achieved by influencing the level of protein synthesis, as put forward by F. G. Young[36] and more recently by Cornforth and Long[37], and as confirmed with regard to the growth-retarding effects of corticosteroids in this manner by Clark[38]. The action of androgens and œstrogens on sex organs, apart from their luteinizing and follicle-stimulating activity, turns out to be more and more that of balancing regulators[39], which links the field of normal with that of abnormal growth. There are many chemical problems still unsolved with regard to normal growth and development, and a long list could be prepared which should clearly emerge from this very condensed summary.

[1] Thompson, D'Arcy W., "On Growth and Form" (Camb. Univ. Press, 2nd ed., reprint 1952).
[2] Alexander, J., "Colloid Chemistry", **2**, 59 (New York: Chem. Catalog Co., Inc., 1928).
[3] "Crystal Growth", Discuss. Farad. Soc., No. 5 (1949).
[4] Imperial Chemical Industries Films, Nos. *ADRD*/1, 2, 4.
[5] Hinshelwood, C., *J. Chem. Soc.*, 745 (1952).
[6] cf. Brachet, J., Symp. Soc. Exp. Biol., No. 6, 173 (1952).
[7] Weiss, P., "Chem. and Physiol. of Growth", 135 (Princeton: Univ. Press, 1949).
[8] cf. Needham, J., "Biochem. and Morphogen.", 176 (Camb. Univ. Press, 1950).
[9] Baker, L. E., and Carrel, A., *J. Exp. Med.*, **47**, 353 (1928).
[10] Work, T. S., *Nature* (in the press).
[11] Davidson, J. N., "The Biochemistry of the Nucleic Acids" (London: Methuen and Co., Ltd., 1950).
[12] cf. Todd, A. R., *J. Chem. Soc.*, 647 (1946); and Lythgoe, B., and Todd, A. R., Symp. Soc. Exp. Biol., No. 1, 15 (1947).
[13] Brown, D. M., and Todd, A. R., *J. Chem. Soc.*, 52 (1952).
[14] Markham, R., and Smith, J. D., *Biochem. J.*, **52**, 553 (1952).
[15] Haddow, A., *et al.*, Brit. Emp. Canc. Camp. Ann. Rep., 29 (1951).
[16] Bergel, F., and Bray, R. C. (private communication).
[17] cf. Brit. Emp. Canc. Camp. Ann. Rep., 62, 65 (1950), and 12, 14, 15 (1951).
[18] Pauling, L., and Corey, R. B., *Nature*, **171**, 346 (1953).
[19] Edsall, J. T., *Nature*, **170**, 53 (1952).
[20] *Nature*, **170**, 518 (1952).
[21] Pauling, L., and Corey, R. B., *Nature*, **171**, 59 (1953).
[22] Ambrose, E. J., Brit. Emp. Canc. Camp. Ann. Rep., 24 (1951).
[23] Gale, E. F., and Folkes, J. P., *Biochem. J.*, **53**, 483, 493 (1953).
[24] Dounce, A. L., *Enzymologia*, **15**, 251 (1952).
[25] cf. Haurowitz, F., "Progress in Biochemistry", 365 (New York: Interscience Publishers, Inc., 1950).
[26] Jones, E. R. H., Henbest, H. B., and Smith, G. F., *Nature*, **169**, 485 (1952).
[27] cf. Sexton, W. A., "Chemical Constitution and Biological Activity", Ch. 20, 347 (London: E. and F. N. Spon, Ltd., 1949). Foster, R. J., *et al.*, *Proc. U.S. Nat. Acad. Sci.*, **38**, 1014 (1952).
[28] Haddow, A., and Sexton, W. A., *Nature*, **157**, 500 (1946).
[29] See *Nature*, **171**, 456 (1953).
[30] cf. Goetsch, W., *Naturwiss.*, **33**, 149 (1946).
[31] Weygand, F., and Warker, A., *Z. angew. Chem.*, **62**, 454 (1950).
[32] See Jacobson, W., and Webb, M., *Endeavour*, **11**, 200 (1952).
[33] Baddiley, J., and Thain, E. M., Novelli, G. D., and Lipmann, F., *Nature*, **171**, 76 (1953).
[34] Racker, E., and Krimsky, I., *J. Biol. Chem.*, **198**, 731 (1952).
[35] cf. Gudernatsch, F., Festschrift Emil Barell, Basle, 453 (1936).
[36] Young, F. G., *Lancet*, ii, 955 (1948).
[37] Cornforth, I. W., and Long, D. A., *Lancet*, i, 160 (1953).
[38] Clark, I., *J. Biol. Chem.*, **200**, 69 (1953).
[39] Burrows, H., and Horning, E., "Oestrogens and Neoplasia" (Oxford: Blackwell, 1952).

METAL PHYSICS WORK OF THE DIVISION OF TRIBOPHYSICS, C.S.I.R.O.

By Dr. W. BOAS

Chief, Division of Tribophysics, Commonwealth Scientific and Industrial Research Organization, University of Melbourne

THE Division of Tribophysics of the Commonwealth Scientific and Industrial Research Organization, which began life thirteen years ago as a group studying war-time problems of friction and lubrication, has just moved into its new home in the grounds of the University of Melbourne. The laboratory, a brick building of three stories and a basement, occupies a position in the heart of the University. That a university, already hard-pressed for space, should be willing to give up such an excellent site to a laboratory of the Organization is a tribute to the friendly spirit of co-operation that has developed between the Organization and the universities in Australia.

The work of the Division has broadened from its strictly utilitarian beginnings and now includes a general study of the physics and physical chemistry of solids, particularly metals, and of solid surfaces. The metal physics work of the Division is mainly concerned with the study of the mechanisms of plastic deformation and phase changes, the two main phenomena involved in changing the properties of metals. This work is aimed at a better understanding of the properties and behaviour of metals and alloys, so that the optimum conditions of a material for its various applications can be stated, or alloys developed for new applications.

Thermal Fatigue

One of the first investigations originated from the observation that lead-base bearings withstood repeated heating and cooling as an engine was started and stopped, whereas tin-base bearings showed cracking and surface damage. This difference in behaviour was traced back to the crystal structures of the pure metals lead and tin. The thermal expansion of the cubic metal lead is the same in all crystallographic directions, whereas the tetragonal tin has a coefficient of thermal expansion in the direction of the tetragonal axis twice that in any direction at right angles to this axis. In tin, at the boundaries between crystals of different orientations, free thermal expansion is hindered, and therefore, when the temperature changes, stresses are set up which are large enough to cause plastic deformation and even cracking. In consequence of this effect, polycrystalline specimens of those non-cubic metals which have a large degree of anisotropy of thermal expansion cannot be obtained in a completely strain-free condition.

As the stresses originate at the grain boundaries, they are not uniform in the crystals, and hence the deformation of the crystals is inhomogeneous. Such inhomogeneous stresses have an important effect on the plastic behaviour and failure of metals, and they may arise from various sources.

Inhomogeneity of Plastic Deformation

An obvious cause of macroscopic inhomogeneity is the friction between forming-tool and metal in

industrial methods of deformation, such as drawing and rolling. The inhomogeneity of deformation on a microscopic scale must affect the mechanical properties of polycrystalline metals. If the crystals in an aggregate were independent of each other, the properties of the aggregate would be fully determined by the properties of the crystals and could be calculated by averaging the values of the properties of crystals of all orientations occurring in the aggregate. However, if the aggregate is subjected to stresses, the interaction between the crystals becomes important, as the boundary between any two crystals cannot at the same time suffer two independent deformations.

It has been shown experimentally that, in an aggregate, there are wide differences in the amounts of deformation and work-hardening from crystal to crystal. Moreover, the deformation is not uniform even within any one crystal since it is influenced by that of its neighbours. As a boundary is approached, the deformation becomes larger than at the centre if the average deformation of the neighbour is larger, and in the neighbour the deformation is less near this boundary than at its centre. Thus, a strong crystal supports its neighbours whereas a crystal with a low elastic limit has a weakening effect.

Most of these results were obtained from observations on the surface of the specimen. Special etching techniques, however, made it possible to investigate the behaviour of crystals which, during deformation, were in the interior—that is, surrounded on all sides by other crystals. These crystals behaved in the same way as those in the surface. This was confirmed by a study of duplex alloys, in which the inhomogeneity is due to the different compositions and structures of the crystals of the two phases rather than to their anisotropy.

As it is thus clear that the inhomogeneity of deformation is not a surface effect but occurs throughout the volume of the specimen and is inherent in all crystal aggregates, it has to be taken into account in any theory in which the properties of polycrystalline aggregates are calculated from those of the single crystals.

Recrystallization

One of the methods used in arriving at these results was to observe the recrystallization behaviour of metals and alloys. For this a knowledge of the mode of growth of the new crystals during recrystallization is desirable.

In order to observe the progress of recrystallization continuously, a method was developed using polarized light reflected from the surface of non-cubic metals where the plane of polarization is rotated by an amount depending on the orientation of the crystal. Observations made on zinc show that the growth of a nucleus during recrystallization is very irregular; its extent varies with direction and from point to point in a crystal, and it can stop altogether for relatively long periods.

The observation of irregularity of growth throws doubt on conclusions drawn previously from measurements of the rate of nucleation during the recrystallization of fine-grained specimens. By counting the number of new grains which appeared after various periods of annealing, the apparent nucleation-rate was found to increase with the duration of annealing, and, assuming a constant rate of growth during the period from nucleation to observation, the true rate of nucleation was said to increase too. This conclusion presents a puzzle from the theoretical point of view and cannot be sustained in view of the observed erratic growth of the nuclei. The period during which a growing nucleus remains too small to be observable will be extremely variable, and, for a constant and even slowly decreasing nucleation-rate, the number of unobserved nuclei will increase with time. A certain fraction of these will grow to an observable size in successive units of time, and hence the apparent rate of nucleation will increase though the true nucleation-rate may not.

Mechanism of Plastic Deformation

The plastic deformation of metals occurs mainly by slip within the crystals, and it is now generally assumed that slip takes place through the motion of dislocations. Although the basic idea of the theory —that is, that slip is a localized process—is well founded on experimental results, several rather artificial assumptions have to be made to explain some of the experimental observations. Further, much of the earlier published work used unsuitable materials and methods. Hence, an experimental attack on the problems of slip and work-hardening of metals is being made by measuring the changes produced by deformation in internal energy, X-ray interferences and electrical resistivity.

Previous investigations had shown that about 10 per cent of the work done on a specimen during plastic deformation is stored, whereas the major part is dissipated as heat. The stored energy is liberated on annealing and can be determined as the (small) difference in specific heats of undeformed and deformed specimens with an accuracy of about 20–30 per cent.

Using a differential method, in which deformed and annealed specimens of equal weight are heated simultaneously in the one enclosure, an accuracy of $\pm$ 5 per cent is obtained. The difference in power supplied to the specimens, in order to maintain their temperature difference within 1/20 deg. C., is measured continuously with a specially designed differential wattmeter. The curve showing the release of the stored energy as a function of temperature is thus obtained directly.

Results obtained for specimens of electrolytic copper deformed in torsion show that the stored energy increases with deformation in a similar way to the torque required to produce the deformation. Small amounts of some impurities appear to be responsible for large differences both in the recrystallization temperatures and in the shapes of the curve of released energy against temperature, and may also change markedly the total stored energy. With nickel, about 40 per cent of the stored energy is released in a temperature-range in which the electrical resistivity reverts almost to the lower value of the undeformed metal, whereas removal of both work-hardening and broadening of X-ray diffraction lines occurs at a temperature about 300 deg. C. higher. These results support the suggestion that vacancies generated during plastic deformation are the main cause of the accompanying increase in electrical resistivity.

The electrical resistivity of several metals and alloys was measured at temperatures in the range from $-$ 183 to $+$ 100° C. after various degrees of deformation by wire-drawing which was carried out

in the same temperature-range. The results showed that the behaviour of some metals, notably of tungsten and molybdenum, which formerly had been considered anomalous because of a large relative increase in resistivity, can be explained if the high recrystallization temperatures of these metals are taken into account. Another observation was that, on wire-drawing and rolling, the electrical resistivity of some cubic metals becomes anisotropic. An analysis of the results indicated that the increase in electrical resistivity with deformation may not be caused entirely by dislocations and lattice vacancies, but that stacking faults in face-centred cubic crystals may also play an important part.

Mechanism of Phase Changes

There are two ways in which a transformation in the solid state may occur. First, the atoms may be rearranged to form a crystal of the new structure which has the same external shape as the original crystal. Such transformations involve nucleation and growth of nuclei, and depend on thermally activated diffusion. Secondly, the rearrangement of the atoms may occur in such a way that each atom has the same neighbours in the new structure as it had in the old. This leads to a change in external shape which produces relief effects on polished surfaces. These phase changes occur extremely rapidly, even at temperatures where the rate of diffusion is very small, and proceed only during cooling and not isothermally to any appreciable extent.

As for the mechanism of thermally activated diffusion, it appears that the movement of atoms is connected with that of lattice holes. The development of the theory may be assisted by investigating the effect of atomic packing on the rate of diffusion, and for this reason the rate of self-diffusion was measured in various directions in tin crystals, as these show anisotropy of the diffusion-rate and no chemical complications occur, since only one type of atom is involved. It was found that the activation energy for diffusion along the tetragonal axis was about one and a half times that for diffusion in any direction at right angles to it, and the geometrical factor was about forty times larger for the tetragonal axis. However, it has not been possible to correlate the activation energy with such other physical properties as are mainly determined by the energy with which the atom is bound to its equilibrium position in the structure.

The investigation of 'diffusionless' transformations is particularly attractive, as it is hoped that from their features the movement of the atoms during the transformation may be deduced. An attempt is now being made to determine the atomic movements in transformations which produce changes in external shape, although they occur by thermal diffusion. The fact that the orientation of the new crystals is related to that of the matrix suggests that the mechanisms by which nucleation-growth and diffusionless transformations occur may not be as fundamentally different as was previously thought.

The work described in this paper is the result of close collaboration of a number of workers, and it is difficult to disentangle the individual contributions. For this reason no reference has been made to particular publications.

OBITUARIES

Dr. R. W. Gurney

Dr. Ronald Gurney, who died at his home in New York on April 15 at the age of fifty-four, was born in Cheltenham and was educated at Cheltenham College. After service in the Gloucestershire Regiment in the First World War, he went to Cambridge, where he was an undergraduate at Trinity Hall. He began his career as a scientist at the Cavendish Laboratory under Rutherford, where he carried out experiments on the ionization by fast particles and published a number of papers on this subject. It was during a visit to the United States, however, that he made in 1929 the first of those striking incursions into theoretical physics by which he will be mainly remembered; in collaboration with E. U. Condon, he gave the first correct explanation of α-decay in terms of wave mechanics, anticipating by several months the similar but more detailed treatment of Gamow. From this time onwards he became a theorist; after some years at Manchester with W. L. Bragg, he came to Bristol in 1935 and worked with me. We produced jointly the book "Electronic Processes in Ionic Crystals", and also a theory of the nature of the photographic latent image, much—if not all—of which has stood the test of time. In addition, he worked on the theory of liquids, and in Manchester and Bristol he laid the foundation of his future work on ions in solution.

In 1941 Gurney went to the United States and worked first at the Ballistic Research Laboratories of the Aberdeen Proving Ground, then at the Argonne Atomic Laboratory, at the Johns Hopkins University, and finally at the University of Maryland.

Gurney's publications include the books "Elementary Quantum Mechanics" (1934), "Ions in Solution" (1936), "Introduction to Statistical Mechanics" (1949) and "Ionic Processes in Solution", recently published by the McGraw-Hill Book Co. It was typical of him that, though he could use mathematics as well as another, he never trusted it; no theory was a theory to him until he could grasp it intuitively and, above all, draw diagrams of it. In this he was among theorists perhaps the truest representative of Rutherford's school, and of the British tradition. Wherever Gurney went—and not least at Bristol—he contributed to the work of the place a capacity to see things clearly, graphically, and in their essentials. He was a man with whom it was a privilege to work, and from whose unique qualities of mind and character his collaborators could learn much.

In 1950 Gurney had a stroke, and although he recovered well he was advised not to incur the strain of regular lecturing. During his last three years he was able, with the constant help of his wife Mrs. Natalie Gurney, to devote himself to his last book, which has appeared since his death. His many friends and colleagues will look forward to another example of his unique ability to make the complex simple and to get to the heart of things.

N. F. Mott

Dr. C. E. M. Joad

Dr. C. E. M. Joad was reader in philosophy in the University of London and head of the Department of Philosophy, Birkbeck College. By his recent death, philosophy has lost one of its most lucid expositors and teachers. A list of his writings shows how wide were his interests. He was not satisfied until he had

studied the philosophical bearings of modern developments in science, in the theory and practice of politics and in changes in manners and morals. When his thinking led to a major change in his personal beliefs, he explained his reasons and his readers had the full benefit of his experience. He thought aloud and on paper, and he dealt with no problem which he did not illuminate. His favourite saying was that if anything could be said, it could be said clearly, and certainly he never said or wrote anything vague or obscure. This may sometimes have led him to oversimplify some problems and to do less than justice to the more subtle points, but his readers have nothing to unlearn; they are beguiled into a deeper study of the problems set out in such a clear and stimulating way in Dr. Joad's various guides to philosophy. These books are models of what an introduction to a difficult subject should be.

In his own philosophical thinking, Dr. Joad was in the unfortunate position of having outgrown the Idealistic teaching of his Oxford days, and of being out of sympathy with the modern school, though he never ceased to admire the brilliance of its leading thinkers. He thought he had found the key to much that is unsatisfactory in modern thinking and conduct in the 'dropping of the object' in our judgments of value, a view that is presented brilliantly and provocatively in his study of decadence. He was happiest in the writings of the ancients, and he had the faculty of presenting their problems as though they were fresh and contemporary. To hear him lecture on the Nicomachean ethics of Aristotle was an unforgettable experience.

Dr. Joad esteemed it a privilege, and the source of his greatest satisfaction, to have been able to guide the thinking of so many young people. Thousands of students, inside and outside university walls, owe to him the discovery that it is exciting to think and a duty to think clearly. He will be missed far more than he would have expected, for he was essentially a humble man.

Mr. W. Birtwistle

Mr. W. Birtwistle died at Skibbereen, Co. Cork, on March 4, within two days of his sixty-third birthday. Educated at Blackburn Grammar School, he served in the First World War, and in 1920–24 studied oceanography and fisheries under the late Prof. James Johnstone in the University of Liverpool. In 1925 he took up duty as fisheries economist, in charge of the Fisheries Department, Straits Settlements, and Federated Malay States, later assuming the title of director of fisheries. He retired in 1945.

Mr. Birtwistle was a pioneer of fishery development in the Far East, with especial attention to the introduction of power-driven fishing craft, and the cultivation of fish in rice fields. These and many other developments he sponsored were published in the annual reports of the Malayan Fisheries Department. He could foresee future developments in Asia, and made provision for the advanced training of Asian staff in the late 1930's. The wisdom of this has already been shown in the good work done by these men. He was highly respected by the fishermen, and on his death tributes were paid by men of all nationalities in Malaya.

NEWS and VIEWS

Sedleian Chair of Natural Philosophy at Oxford: Prof. Sydney Chapman, F.R.S.

The retirement of Prof. Sydney Chapman from the Sedleian chair of natural philosophy at Oxford has just been announced. Prof. Chapman reaches the age limit after occupying this chair since 1946. Before going to Oxford (see *Nature*, **157**, 155; 1946) Prof. Chapman had been at the Imperial College of Science and Technology, London, for no less than twenty-two years. Fortunately, his departure from Oxford is not going to hinder his interests in geomagnetism and the upper atmosphere, for he is to continue as professor of geophysics at the University of Alaska, an appointment which he has held since 1951 in addition to his work at Oxford. His many friends all over the world will be glad to think that in this way he will be able to increase the very considerable debt that is already owed to him by workers in those fields which are peculiarly his own, and where his influence will remain for many years to come.

Prof. George Temple, F.R.S.

The appointment has been announced of Prof. George Temple to succeed Prof. Chapman. Like his predecessor, Prof. Temple has wide interests. Educated at Birkbeck College, London, and Trinity College, Cambridge, he held teaching posts at Birkbeck College (1922–24), at the City and Guilds College (1924–28) and at the Royal College of Science (1928–30) before being appointed to the chair of applied mathematics at King's College, London, a position which he has held with great success for the past twenty-one years. Prof. Temple was elected a Fellow of the Royal Society in 1943. His earlier researches were in mathematical physics and relativity, to be followed by a vigorous and highly productive application to the quantum theory when this was developed in the late 1920's. A text-book on Rayleigh's principle and another on the general principles of the quantum theory bear evidence of these interests. More recently he has been occupied with problems in aerodynamics, and has become one of the leading theoretical experts in the subject in Britain. He will be most welcome at Oxford, where his wide knowledge of mathematics will help to supplement that of his colleagues, and where his considerable administrative experience and easy charm of manner will prove most valuable.

Letters to Sir William Siemens

A collection of more than two hundred and fifty letters written by men of science, statesmen, artists and other notable personalities to Sir William Siemens, the distinguished scientist and engineer of the nineteenth century, has recently been acquired from a relative of Lady Siemens by Sir George Nelson, chairman and managing director of the English Electric Co., Ltd. These letters, arranged chronologically, have been mounted in two special volumes with the printed text on facing pages, together with a short biography of Siemens written by W. H. Kennett, short notes on the authors of the letters and an index. A third volume, made up of the printed copies of the letters, the biography, etc.,

and facsimile copies of twenty-two of the letters (which to the inexpert eye are scarcely distinguishable from the originals), was presented by Sir George on May 14 to the Institution of Electrical Engineers. In addition, a thousand copies of a general edition of the letters have been printed and will be presented to universities, libraries and engineering societies. The letters are very mixed in content and personality of author, but they serve a useful purpose in revealing the wide interests of Siemens and in reflecting the manners of the times in which he lived. The letters written by men of science form a minority, but they are a notable array; his correspondents included Airy, Bessemer, Crookes, Darwin, Dawson, Faraday, Fowler, Hooker, Helmholtz, Huxley, Kelvin, Lockyer, Maxwell, Rankine, Rayleigh, Roscoe, Tyndall, Wheatstone and Whitworth. That by Sir Norman Lockyer, the astronomer and founder-editor of *Nature*, deals with a previous statement made by him that there is no oxygen to be detected spectroscopically in the sun's chromosphere. The letters range in date from one of a number by Faraday in 1862 to one by Lady Kelvin in 1902 deploring the death of Queen Victoria and looking forward, with very mixed feelings, to the Coronation of Edward VII.

Committee on the Effects of Synthetic Detergents

The Minister of Housing and Local Government, Mr. Harold Macmillan, has stated that, after consulting the Secretary of State for Scotland and the Minister of Health, he has appointed a committee with the following terms of reference: "to examine and report on the effects of the increasing use of synthetic detergents and to make any recommendations that seem desirable with particular reference to the functioning of the public health services". The committee is constituted as follows: Sir Harry Jephcott, chairman and managing director of Glaxo Laboratories, Ltd. (chairman); Dr. N. R. Beattie, principal medical officer, Ministry of Health; C. E. Boast, borough engineer and surveyor, County Borough of Croydon; Prof. J. C. Cruickshank, professor of bacteriology as applied to hygiene, London School of Hygiene and Tropical Medicine; G. H. W. Cullinan, general manager, Shell Chemicals, Ltd.; Lt.-Col. E. F. W. Mackenzie, director of water examination, Metropolitan Water Board; G. MacRobbie, assistant secretary, Department of Health for Scotland; F. D. Morrell, director, Unilever, Ltd., London; Dr. J. R. Nicholls, deputy government chemist; F. T. K. Pentelow, chief inspector of salmon and freshwater fisheries, Ministry of Agriculture and Fisheries; Dr. B. A. Southgate, director, Water Pollution Research Laboratory, Department of Scientific and Industrial Research; H. Symon, undersecretary, Ministry of Housing and Local Government; W. L. Thomas, chief chemist and technical director, Woolcombers, Ltd., Bradford; C. B. Townend, chief engineer, main drainage, Middlesex County Council; R. Craig Wood, managing director, Thomas Hedley and Co., Ltd., Newcastle upon Tyne. *Technical Officers:* Dr. E. A. B. Birse, chief inspector of alkali works and rivers pollution, Department of Health for Scotland; Lt.-Col. F. G. Hill, adviser on sewerage and sewage disposal, Ministry of Housing and Local Government; Dr. A. Key, senior chemical inspector, Ministry of Housing and Local Government. The secretary to the committee is Mr. A. R. Isserlis, Ministry of Housing and Local Government.

Geological Society of Australia

The recently constituted Geological Society of Australia grew from groups of geologists who have met more or less informally during the past few years at various centres in the Commonwealth. The Society has been organized on a Federal basis with State divisions, local branches at appropriate centres, and a Federal Council governing the whole. While membership is being established in the several States (including the Federal Territories), the Society is functioning under a Provisional Council with Prof. E. S. Hills as chairman. Formal elections are to be held in June. The first publication of the Society, No. 1 of the *News Bulletin*, has appeared (March 1953) and plans for the issue of a *Journal* are well advanced. No papers will appear in the *News Bulletin*, the function of which is intended to be the welding of closer personal bonds between Australian geologists. The first issue is of lively interest and contains many items of personal news besides summaries of work in progress. The New South Wales Division, for example, has reports from the University of Sydney, New England University College, the Geological Survey, a number of museums and public authorities, and various mining companies in the Broken Hill district.

Noteworthy news items include the following. A late Pre-Cambrian tillite has been discovered in the north of Western Australia. The heat-flow in Tasmania is being measured by the Geophysics Department of the National University. Prof. S. W. Carey is spending a sabbatical year developing his views on continental drift. Prof. E. S. Hills is completing a study of Upper Devonian cauldron subsidences in Victoria including one fifteen miles across. Some of the members of Prof. C. E. Marshall's staff at Sydney are engaged in investigating the geology of the Solomon Islands and parts of Papua; a recent graduate has been "well-sitting" (*sic*) with an oil company; and a teaching fellow "has resigned to enter the church". Altogether the *Bulletin* should add considerably to the gaiety of Australian—and not only Australian—geologists. But it closes on a more sombre note with an obituary notice of the late Prof. E. W. Skeats, who died in January at the age of seventy-eight. Judging by the response of Australian geologists to the demands and privileges of their new Society, success would seem to be well assured. The first issue of the forthcoming *Journal* will be eagerly awaited.

The Spirit of Applied Mathematics

Under the title of "The Spirit of Applied Mathematics", Prof. C. A. Coulson gave his inaugural lecture on October 28, 1952, as Rouse Ball professor of applied mathematics in the University of Oxford, and the text of the lecture has now been published (pp. 24. Oxford: Clarendon Press; London: Oxford University Press, 1953. 2*s.* 6*d.* net). After tributes to the founder of the chair, to his own predecessor, Prof. E. A. Milne, and to the mathematician – physicist – biologist, D. E. Lea, Prof. Coulson said that applied mathematics is, more frequently than not, misunderstood. Even its name is against it, as it suggests that it is a mental rag-bag in which one can rummage to find a bit of unused mathematics applicable to the latest discovery in experimental physics. But really the glory of applied mathematics, he continued, is not in such applications but in the creation of concepts, an intellectual adventure which combines creative imagination and

canons of beauty to give insight into the nature of the world. Lying between pure mathematics and the experimental sciences of physics and chemistry, the results of which remain substantially unaltered, applied mathematics has the surprising difference that it is liable to rapid changes, and its progress consists of the creative process of finding a new set of concepts to transcend the old. The value of such concepts does not depend on their permanence, and some of the best, for example, Bohr's theory of the atom, did not survive unchanged for more than a generation. The essentials, said Prof. Coulson, are the joy, passion and creative impulse, the search for beauty, simplicity and integrity in structure and form, set in an environment partly dependent on, and yet in its deepest sense independent of, experiment and pure mathematics.

Sea Foam

SOMETIMES, after heavy and prolonged onshore storms, great masses of foam are drifted in from the sea on to local rocks and beaches. A curious feature of these lather-like masses is the way in which they persist for relatively long periods even when blown about by the wind. Ordinary lathers soon revert to their former unlathered state; but sea foams may persist for a day or more when the weather continues moist and stormy and no sun shines. It is possible that the foam is 'held' by the presence of some protein material, and Miss E. M. Moore suggests that this protein material might be found in the alginate products of sea-weeds. This, however, does not explain how the surface tension of sea-water could be so lowered that the whipping action of storm waves could create a frothy mass (*Aust. Mus. Mag.*, **10**, 11; 1952). A likely explanation of the phenomenon is that, during storms, large numbers of planktonic organisms are destroyed and broken up because of the battering they receive in choppy seas. The surface tension-lowering chemicals which are thus released into the sea-water would allow the waves to whip up a froth and, if there is also present enough protein matter released from the alginate, a foam with lasting qualities might result.

Surface Photometry of Southern Elliptical Nebulæ

A PAPER by Dr. David S. Evans on "Surface Photometry of Southern Elliptical Nebulæ", which has been published as No. 19 in the series of "Communications from the Radcliffe Observatory, Pretoria" (reprinted from *Mon. Not. Roy. Astro. Soc.*, **111**, 6; 1952), discusses the surface brightness of a group of seven elliptical nebulæ in the region R.A. 3h. to 4h. 30m. Of these nebulæ, four are in pairs and each pair can be photographed on one plate. There is a description of the various details pertaining to the photography, etc., connected with the work, followed by a discussion of the results, which are shown in seven diagrams, these isophotes being drawn with an interval of 0·5 magnitude. In these the dotted lines represent Hubble's distributions in accordance with his law $m = m_e + 5 \log (r/a + 1)$, where r is the distance measured along a radius and a is a constant. While the maps do little more than confirm Hubble's results, there are certain differences of detail which can best be seen in the plot of *NGC* 1291, the latter showing re-drawings of the central isophotes. There is an obvious rotation of the line of the major axes of successive isophotes, and the natural interpretation of this would be a shear due to rotation. It is asserted that this phenomenon is very probably real in the case of *NGC* 1291, and Evans thinks that this also applies to *NGC* 1549, although the effect is not so well marked. *NGC* 1553 presents some anomalies and resembles two elliptical nebulæ, one seen behind the other, though there is no suggestion that this is so. While it scarcely seems correctly classified as a spiral, as an elliptical nebula it is atypical. Observational material on the remaining bright southern elliptical nebulæ is being accumulated, and it is hoped that a detailed discussion will follow in due course.

Papain

DERIVED by tapping the mature but unripe green fruits of the papaw (*Carica papaya*), the proteolytic enzyme papain has for a number of years received considerable attention from planters although its market is at present confined largely to the United States. The papaw is indigenous to tropical America, but its cultivation has spread to most tropical countries and its commercial production has hitherto been confined principally to Ceylon and British East Africa (*Col. Plant and Animal Prod.*, **3**, No. 1; 1952–53). In the United States papain has five main uses. In the brewing industry it is used for 'chill proofing' beer, while other important applications are in medicine and pharmaceutical preparations; in the food industry, in pre-cooked foods and in the manufacture of meat-tenderizing preparations; and, in the textile industry, particularly in shrinkage resistance and other treatment of wool, wool and silk mixtures, and perhaps in silk processing. Papain is used to a much more limited extent in the United Kingdom, and the chief applications may not extend far beyond pharmacy and textiles. In other countries there would appear to be use for papain in the brewing industry.

Canadian Association of Physicists: Annual Congress in London, Ontario

THE ninth annual congress of the Canadian Association of Physicists will be held during May 28–30 in the University of Western Ontario, London. Prof. J. T. Wilson, professor of geophysics in the University of Toronto and formerly war-time director of operational research in the Canadian Army, will be the after-dinner speaker at the Association's dinner on May 28, and the presidential address on the structure of physical theories will be delivered on May 29 by G. C. Laurence, of Atomic Energy, Ltd. A reception by the board of governors of the University of Western Ontario will follow. The remainder of the programme of the congress will consist of contributed papers, a symposium on the physics of metals, and two invited papers by Prof. M. S. Vallarta, of the El Collegio Nacional de Mexico, on cosmic-ray physics, and by Dr. H. L. Anderson, of the University of Chicago, on the nature of the π-meson.

Eighth Pacific Science Congress: Meeting in the Philippines

THE Eighth Pacific Science Congress will be held in the Philippines (in Quezon City, Manila, Los Banos and Baguio) during November 16–28, with headquarters in the Liberal Arts Building, University of the Philippines, Quezon City; concurrently with this, the Fourth Far Eastern Prehistoric Congress will take place. The programme for the Pacific Science Congress will be organized under the following twelve headings: geology and geophysics, meteorology, oceanography, zoology, botany, soil resources,

forestry, agriculture, anthropology, public health, nutrition and social sciences. General symposia will be held as follows: rice enrichment; Pacific oceanography; management and utilization of natural resources; geology and mining industry; plant geography; typhoons; anthropological subjects (with special emphasis on recent archæological finds, outstanding ethnographical studies and problems, and recent work in linguistics); historic and prehistoric population movements into the Pacific and major lines of migration; crop improvement; animal improvement in the Pacific; reforestation; Pacific conservation; museums; international organizations of the United Nations, etc. In addition, there will be two special symposia. Besides those who will be at the Congress as official members or members (the latter being appointed by representative institutions or accredited by scientific societies), interested persons may attend the Congress as 'participants'; British scientific workers who wish to attend should write in the first place to the Assistant Secretary of the Royal Society, Burlington House, London, W.1. Papers will be limited to ten minutes for reading and five minutes for discussion; all papers (and abstracts of not more than four hundred words) must be sent in by September 1. Further information can be obtained from the Secretary-General, Eighth Pacific Science Congress, National Research Council of the Philippines, Quezon City, Philippines.

Royal Society of South Africa: Council for 1953

At the anniversary meeting of the Royal Society of South Africa, held on March 18, the following members of Council were elected for 1953: *President*, S. H. Skaife; *Honorary General Secretary*, W. J. Talbot; *Honorary Treasurer*, N. Sapeika; *Acting Honorary Editor of Transactions*, A. M. Talbot; *Honorary Librarian*, E. Newbery; *Other Members of Council*, R. S. Adamson, D. Burnett, W. J. Copenhagen, A. J. H. Goodwin, S. H. Haughton, W. E. Isaac, W. J. Lutjeharms, R. H. Stoy and C. van Riet Lowe.

Society for Endocrinology: Officers and Committee

Officers and committee for 1953 of the Society for Endocrinology have been elected as follows: *Chairman*, Dr. S. J. Folley; *Honorary Secretaries*, Prof. C. H. Gray and Prof. N. F. Maclagan; *Honorary Treasurer*, Dr. G. W. Harris; *Editor of the Society's Proceedings*, Prof. S. Zuckerman; *Ordinary Members of the Committee*, Dr. T. Mann, Dr. C. J. O. R. Morris, Dr. I. W. Rowlands and Dr. S. L. Simpson. Communications should be sent to Prof. C. H. Gray, secretary of the Society, at the Department of Chemical Pathology, King's College Hospital, Denmark Hill, London, S.E.5.

Announcements

A meeting arranged jointly by the Acoustics Group of the Physical Society and the Royal Aeronautical Society on the subject of aeronautical acoustics, and jet noise in particular, will be held at the Institution of Mechanical Engineers on May 21. There will be three sessions on engine, aircraft and ground noise, respectively, and a general discussion will follow. Further information can be obtained from the General Secretary, Royal Aeronautical Society, 4 Hamilton Place, London, W.1.

An exhibition of the Flinders Petrie collection of Egyptian antiquities will be held in the Museum of Egyptology, University College, Malet Street, London, W.C.1, during June 18–August 31 (admission free; Monday-Friday, 10 a.m.–5 p.m.; Saturday, 10 a.m.–noon). The Flinders Petrie centenary lecture will be given by Prof. S. R. K. Glanville, Herbert Thompson professor of Egyptology in the University of Cambridge; the lecture will be open to the public and will be given in the Anatomy Theatre, University College, Gower Street, London, W.C.1, at 5.30 p.m., on June 17.

The summer conference of the Society for Applied Bacteriology will be held in Oxford during July 6–9. On July 7 a symposium will be held on "Antibiotics, their Production and Uses in Industry", at which papers will be read on antibiotic-producing organisms, antibiotic fermentations and their biological control, the chemistry of some antibiotics and their uses in the control of plant diseases and animal feeding. The remainder of the conference will consist of original contributions. Further details may be obtained from the Honorary Secretary, G. Sykes, Boots Pure Drug Co., Ltd., Microbiology Division, West Bridgford, Nottingham.

The annual meeting of the Société de Chimie Physique will this year take the form of a discussion on "Recent Advances in the Study of Molecular Structure", to be held in Paris during July 6–10. The various topics will each be introduced by a general summary given as follows: Sir John Lennard-Jones, principal of the University College of North Staffordshire, recent advances in our knowledge of the chemical bond; Prof. R. Mecke (Freiburg im Breisgau), recent advances in the field of spectroscopy; Prof. Roubine (Lille), microwave spectroscopy; Mr. Grison (Bergerac), localization of hydrogen atoms by X-ray diffraction; Dr. L. E. Sutton (Oxford), electron diffraction; Prof. Cauchois (Paris), X-ray spectra; Dr. G. E. Bacon (Harwell), neutron diffraction; Dr. M. Lederer (Paris), determination of the molecular structures of natural organic substances. Further information can be obtained from the general secretary of the Société de Chimie Physique, Prof. G. Emschwiller, 10 rue Vauquelin, Paris 5e.

At the combined invitation of the Amsterdams Chemisch Dispuut, the Utrechtse Chemische Club and the Chemisch Dispuut Leiden, Prof. John Read, of the University of St. Andrews, has recently given a series of lectures in the three Dutch universities concerned, beginning at Amsterdam on April 27. In meeting the special request of these three student societies, Prof. Read dealt with the subject of alchemy and its connexions with art and music, and in particular with the art of the Netherlands. The lectures were accompanied by artistic and musical illustrations, and it is a tribute to the linguistic abilities of Dutch students that at each centre the whole of the proceedings, including questions and discussions, were conducted in English. At Amsterdam, in the laboratory of Prof. J. P. Wibaut, Prof. Read also gave an account to advanced and research students, and members of the teaching staff, of some of his own collaborative researches on the chemistry and stereochemistry of plant products, originating in the University of Sydney and continued at St. Andrews.

Erratum. In the communication "Kramer and Russell Effects with Single Crystals of Zinc" in *Nature* of May 16, p. 890, by Dr. L. Grunberg and Dr. K. H. R. Wright, the descriptions (*a*) and (*b*) below the illustration should be interchanged.

CHEMISTRY AND PHYSICS IN SPAIN

DURING the period April 15–21 the Real Sociedad Española de Fisica y Quimica celebrated its fiftieth anniversary. The proceedings opened with an official reception at which representatives of various foreign chemical and physical societies presented congratulatory addresses, followed by an address on the Society itself by the president, Prof. M. Lora Tamayo. Witness was given to the importance with which science is regarded in modern Spain by the fact that on the dais no less than four ministers of State were present, namely, the Ministers for External Affairs, for National Education, for Industry, and a Minister representing the Sub-Secretariat of the Chief of State. In attendance were the majority of the ambassadors of the foreign delegates. The Minister for National Education welcomed the foreign delegates to Spain.

The actual work of the conference was preceded by a Requiem Mass in the Church of Consejo Superior de Investigaciones Cientificas. Four days were devoted to colloquia and to the communication of papers on original work carried out by Spanish men of science. In addition, a number of open lectures were given on special themes. These included the following: the physical limits of vision, by Prof. J. M. Otero; lignin and its formation, by Prof. K. Freudenberg; the total synthesis of nucleic co-enzymes, by Prof. A. R. Todd; the determination of geological age by isotopic methods, by Prof. Otto Hahn; diene synthesis in natural products, by Prof. Kurt Alder; the role of chromatography, by Prof. A. Tiselius; and electrochemical polarization, by Prof. A. Rius. These alone indicate the truly international character of the meeting.

The meeting also gave opportunity for a reunion of the International Commission on Optics and for the officers of the International Union of Chemistry to discuss the forthcoming meeting at Stockholm.

The Minister for Industry welcomed the delegates and showed them around the permanent exhibit of the activities of the Instituto Nacional de Industria. This is a truly impressive display of the industrial activities which are being developed in Spain. Research work on the lines of that in Britain by the Department of Scientific and Industrial Research is being carried out to the large pilot-plant scale in Madrid on various topics. These include the treatment of shale for the production of lubricants and the utilization of waste raw materials of vegetable origin such as grape stones, sprouts, vine shoots and straw by the process of fermentation followed by briquetting of the non-hydrolysable residue. It is contemplated that 30,000 metric tons a year of yeast for animal consumption, 24,000 tons of petrol and higher ketones for motor fuel, 35,000 tons of wood preservatives and 145,000 tons of charcoal will be produced, together with acetone, methanol and other by-products. The pilot plant has operated successfully, and engineering drawings for the larger plant are now almost completed.

The Instituto Nacional de Industria participates with private firms in a great number of industrial operations which are required for the reconstruction of the national economy in Spain. The outcome of this welding together of national effort and private enterprise will certainly be a matter which the rest of the world cannot ignore.

As will be seen from this brief account of the proceedings of the anniversary meeting of the Society, attendance at and participation in the scientific meetings were tasks of no mean order. In addition, the proverbial Spanish hospitality was on a truly lavish scale, including opera, dinners and tours. Spanish men of science can, at least so far as the foreign delegates are concerned, rest assured that the anniversary celebrations of their Society was an event of outstanding interest. ERIC K. RIDEAL

RUMFORD BICENTENNIAL SYMPOSIA AND AWARDS

MARCH 26 was the two-hundredth anniversary of the birth of Benjamin Thompson, Count Rumford, who although an American by birth, has left his mark on European science and technology. Apart from his purely scientific achievements, he is best remembered in Britain as the founder of the Royal Institution; he also established the Rumford Medals, one series of which is awarded by the Royal Society and another by the American Academy of Arts and Sciences, the latter for work carried out in America only.

To celebrate the anniversary, the American Academy of Arts and Sciences organized a conference in Boston to which were invited all former Rumford medallists, but which was also open to the scientific public. A great number of the American medallists were present, as well as four medallists of the Royal Society—Sir Alfred Egerton and Prof. F. E. Simon from Britain, Prof. M. Siegbahn from Sweden and Prof. P. Debye from the United States. The celebrations started with a banquet given by the American Academy in the Harvard Club at Boston; the president of the Academy, Dr. Edwin H. Land, of 'Polaroid' fame, presided, and Sir Alfred Egerton transmitted the greetings of the Royal Society and of the Royal Institution. The menu included Rumford's famous soup which he devised for feeding the poor; fortunately, as part of an opulent dinner it produced none of the bad effects it had when for a time, about a hundred years ago, it became the sole diet of the inmates of a British prison! The main speaker was Prof. Sanborn Brown, who gave a very informative and amusing talk on Rumford as a physicist and technologist, and also presented a picture of his personality which made it clear why Rumford was not too popular with many of his contemporaries.

The first symposium was held on the morning of March 27 in the rooms of the Academy and dealt with recent developments in thermodynamics. Prof. P. W. Bridgman spoke on "Reflections on Thermodynamics", Sir Alfred Egerton on "Management of Flame", Prof. L. Onsager on "Reciprocal Relations in Irreversible Processes" and Prof. F. E. Simon on "Helium and the Range of Stability of the Solid State". In the afternoon another symposium took place on recent developments in atomic spectroscopy; Prof. M. Deutsch discussed "Positronium", Prof. W. E. Lamb, jun., "Excited Hydrogen Atoms", Prof. E. M. Purcell "Line Spectra in Radio Astro-

nomy" and Prof. I. I. Rabi "Molecular Beam Radio-frequency Methods for the Study of Excited States of Atoms".

In the evening, Rumford Medals were presented by Dr. Land to Profs. E. Fermi, W. E. Lamb and L. Onsager, who were introduced by Profs. P. Debye, N. F. Ramsey and J. G. Kirkwood, respectively. After the ceremony a reception for the Rumford Medallists was held in the very pleasant rooms of the American Academy of Arts and Sciences. There was also an opportunity of visiting an exhibition of Rumford's scientific works.

On March 28 there was a final symposium on recent developments in nuclear physics. The speakers were Prof. E. Fermi on "Meson Physics", Prof. J. R. Oppenheimer on "Recent Progress in the Understanding of Nuclear Forces", Prof. M. Siegbahn on "Nuclear Spectroscopy" and Prof. V. F. Weisskopf on "Problems of Nuclear Structure". All the symposia were followed by lively discussions, and as there were not more than about a hundred people present the intimate atmosphere contributed very much to the outstanding success of the meetings.

The symposia were organized in a quietly efficient way, and the guests were sincerely grateful for the gracious and generous hospitality accorded to them. Their thanks are due to the officers and staff of the American Academy, in particular to Prof. Harlow Shapley, the chairman of the Rumford Bicentenary Committee, and to Mr. R. W. Burhoe, the executive officer of the Academy. F. E. Simon

THE BRITISH DYESTUFFS INDUSTRY

THE address, "Our Changing Chemical Industries: an Appraisement", which Dr. Herbert Levinstein delivered to the British Association of Chemists on February 27 on the occasion of the award to him of the Hinchley Medal, further expounds a disturbing passage in Sir Henry Tizard's Messel Memorial Lecture last July. Sir Henry Tizard had expressed disquiet at Britain's apparent lack of success in competing in the world's markets for chemicals, and quoted figures to show that our share of world trade in chemicals had gone down steadily from 22 per cent in 1913 to 18 per cent in 1950. Germany had been out of the world's markets twice in this period and her share fell from 37 per cent in 1913 and 36 per cent in 1937 to 11·5 per cent in 1950. Dr. Levinstein recognized that the chemical industry in Britain is changing in character as, in accordance with the general tendency to expansion across industrial frontiers rather than within them, firms like the Distillers' Co. and the petroleum firms have extended their manufacturing activities far beyond their original field. There are now in Britain half a dozen firms, with large capital, making chemicals, whereas formerly there was only one; however, we have not yet begun to reap full advantage of the operations of these big companies.

These changes should substantially strengthen the chemical industry of Britain, diminish dollar imports and help exports; but nevertheless, Dr. Levinstein urged that there is much to justify Sir Henry Tizard's misgivings. Arguing that in Britain, as in Germany and in Switzerland, the dyestuffs industry is the foundation of organic chemical industry, he suggested that consideration of the beginnings of this industry, the reasons for its leaving its birthplace in Britain, and its growth to really gigantic proportions in Germany would explain much that has disturbed Sir Henry Tizard. Reviewing the beginnings of the industry and its decline in Britain by the 'seventies, Dr. Levinstein said that the absence of a patent law in Germany until 1877 and, until much later, in Switzerland, and of any provision in British patent law for working in Britain, allowed German and Swiss inventors to take out British patents without obligation to manufacture here, while during this period they could infringe British or other patents in their own countries. The weakness of the British patent system was also exploited by the Germans during 1877–1914, after the Imperial patent law of 1877 embodied Caro's definition of a chemical invention, namely, the obtaining of a new and unexpected technical effect.

The imposition in Britain of the same duty on pure alcohol for industrial purposes as on potable spirits also gave a great advantage to the Germans, and this was not modified until nearly thirty years later when the Government wished to make cordite. A further factor was the difficulty in obtaining capital for new and risky developments, a position which persisted until the comparatively recent formation of the Finance Corporation for Industry. Dr. Levinstein dismissed as irrelevant the view that the superior education of the German chemist or the neglect of research by the British manufacturer had played any real part in the transfer of the dyestuffs industry to Germany. It is true, he said, that training in organic chemistry was better in Germany and in Switzerland than in Britain in the early years of the period. The first large and distinguished school of organic chemistry in Britain was under W. H. Perkin, jun., at the Victoria University, Manchester; but there was never any difficulty in obtaining good German, Swiss, or British chemists from abroad. As regards research, Dr. Levinstein claimed that more research was carried out by his firm at Blackley than was justified by the sales, and that, although on a modest scale compared with that of the Germans, far more research was done there than by any other firm in Britain.

Reviewing the achievements in restoring the British industry on the outbreak of war in 1914, and which, in fact, prevented the Germans from using their stocks of dyestuffs for bargaining at the Peace Conference, Dr. Levinstein pointed out that in 1919 imports into Great Britain had fallen to 3,232 tons from 18,900 tons in 1913, and that we were already exporting 5,446 tons. Although the British range of dyes was incomplete and the plants employed were not necessarily the best for peace conditions, the back of the task was broken and a large research organization had been established. Delays in implementing the promise to introduce the Dyestuffs (Import Regulation) Act and other political and economic factors led to the partial dispersal of the research and technical staff; but Dr. Levinstein expressed his concern that a recent book, "Twenty-five Years Ago, the Story of the I.C.I. Merger", issued by Imperial Chemical Industries, Ltd., had not given a fair account of what had been done to re-establish the British dyestuffs industry before that combine was formed. He also contested the claim that the Dyestuffs Act was only intended to protect the home market and not, by securing the home market, to build up exports. The object of the Act was to secure for the home market a wide, substantially complete range of

dyestuffs; but if exports were neglected, overheads would be extravagantly high. The highest export of British dyestuffs before the Second World War was in 1929, and only in that year and in 1937 (5,728 tons) were the figures for 1919 (5,446 tons) and 1920 (6,157 tons) exceeded. In nineteen years under the Dyestuffs Act, nothing was done to increase British exports of dyestuffs.

This, Dr. Levinstein suggested, had some bearing on the figures which caused Sir Henry Tizard concern. Moreover, there had been no further reduction in imports, which averaged 2,325 tons during 1919–26 (including the abnormally high figures for 1920, following the Sankey judgment) and also for 1927–38. The post-war period figures showed improvement. Exports increased to 12,148 tons in 1950 and 12,486 in 1951, and thus do not substantiate the claim that the German firms have recovered their lost ground. On the other hand, imports increased from 786 tons in 1950 to 1,657 tons in 1951, and of these last Dr. Levinstein noted that 676 tons came from Switzerland and 220 tons from the United States, as much being paid to these 'hard currency' countries as we paid to Germany in 1913. Dr. Levinstein also noted that there are now thirty-seven dyestuffs makers in Britain, and he concluded his survey by referring to the potentialities of the small firm and the possibility of formidable competition later from the U.S.S.R. in dyestuffs and in other chemicals.

FOOD PRODUCTS FROM PLANTS

THE Nutrition Panel of the Society of Chemical Industry, at the third of its series of meetings on "Food and the Future", held in the rooms of the Chemical Society, London, W.1, on March 25, discussed the subject of "Newer Sources of Foodstuffs". Two papers were under discussion: one by Dr. A. C. Thaysen, of the Colonial Microbiological Research Institute, Trinidad, on food and fodder yeast, and the other by Mr. N. W. Pirie, of the Rothamsted Experimental Station, on the efficient use of sunlight for food production.

Dr. Thaysen's paper pointed out that the process of making use of waste material as a medium for the growth of yeast is a measure of our shortage of food. The original idea for the use of yeast as a human food was for children in countries experiencing undernutrition where the need for supplementary protein is most acute. The value of yeast lies in its ability to convert about 80 per cent of the inorganic nitrogen supplied into protein. The rate of conversion, compared with more orthodox methods, is enormous: for example, a fully grown bullock, weighing half a ton, produces protein at the rate of 0·9 lb. per day; half a ton of soya beans at the rate of 82 lb. per day; and half a ton of *Torulopsis* could produce protein at the rate of 51 tons in 24 hr.

Food yeast is at present being produced both in Jamaica and in South Africa. The cost, at 1*s.* 2*d.* per lb., corresponds to 0·069*d.* per lb. of protein, compared with 0·8*d.* per lb. of protein from beef. However, very little yeast is at present consumed by man. In Germany and Finland it is used solely as animal feed, and, if the comparison is then made between yeast and other sources of animal feed, the economic aspect, at the present time, is unfavourable; thus food yeast sells at £130 per long ton, compared with soya bean meal at £30. It is necessary to take into account the presence of an appreciable concentration of vitamins in the yeast. As a supplement to human dietaries, apart from its protein content, yeast would supply much-needed members of the vitamin B-complex and, used in this way, is certainly economical.

In the absence abroad of Dr. Thaysen, his paper was introduced by Mr. H. J. Bunker, who emphasized the future possibilities of food yeast, when present economics could be considered irrelevant. He pointed out that dried brewers' yeast sells at £90 per ton, and when debittered, but not extracted, at £130.

The value of *Torulopsis* as a food converter, compared with *Saccharomyces*, lies in its ability to ferment pentoses as well as hexoses. This is valid only when waste sulphite liquor is used as a medium; when grown on molasses, both these organisms are equally valuable. Vast quantities of raw material are available: for example, as much as a quarter of a million tons of waste sulphite liquor, which really is a waste material, is available annually in the United States and Canada, as well as hydrolysed wood, banana skins, bracken and peat.

Rhodotorula gracilis could provide a valuable addition to fat resources, as the organism contains 42 per cent fat and 23 per cent protein. Earlier reports of the unpalatability of yeast, when it was said that only about 15 gm. per day could be consumed without causing digestive disorders, were probably due to contamination with defrothing agents. Well-prepared yeast is quite palatable.

Mr. Pirie said in his paper that at present we are entirely dependent upon sunlight for our food supplies; but photosynthesis is extremely inefficient. Much of the light is reflected, absorbed by inactive surfaces or by surfaces which are rendered inactive because of unsuitable conditions. The advocates of unicellular photosynthetic organisms, such as *Chlorella*, dispute that farming is the best way to produce food. Algæ have, however, no greater efficiency in trapping sunlight, but can be more readily made to work at maximum efficiency by provision of optimum temperature, carbon dioxide and nutrients. These conditions would render *Chlorella* culture as costly as glasshouse cultivation. It was pointed out later in the discussion, however, that efficiencies up to 20 per cent have been achieved by growing *Chlorella* in the open, as compared with 2–3 per cent for ordinary crops. In addition, the plasticity of metabolism of the organism permits production of food material of any desired composition: for example, 60 per cent protein: 5 per cent fat or 10 per cent protein: 80 per cent fat.

As the green plant will be our main source of food for a long time to come, the best use must be made of it. Only a small part of the crop is eaten directly by man; most is fed to animals or used as a fertilizer, or even wasted. Crops grown primarily as animal food are wasteful, despite the high esteem in which their products are held, because the overall conversion is usually only 5–10 per cent. Economies in the use of soil can be made both here and by replacing textile fibres by synthetic fibres.

The direct consumption of crops by man is desirable. Plants are, however, relatively poor sources of protein, with the exception of legume seeds and most young leaves. Young, vigorously growing leaves contain up to 30–40 per cent protein and little fibre; but only a few plant species will stand up to continuous cropping of very young leaves. The alternative is to separate the fibre from the proteins, fats and carbohydrates of lower-quality leaves. The

advantage of fractionating leafy crops lies in the fact that the products are more valuable when separated than when combined. The proteins are suitable for non-ruminants and perhaps man, the fluid extract could be used for feed or as a medium for micro-organisms, and the fibrous residue, still containing some proteins and starches, is suitable for ruminants or even for fuel.

In many parts of the world there are abundant leafy wastes, such as potato haulms, sugar-beet leaves and sweet potato leaves. When, however, satisfactory techniques have been developed, our choice of domesticated plants might well be reconsidered. Plants that use sunlight most efficiently might be chosen rather than those grown merely because a use has been found for them. On the question of economics, leaf protein, even extracted from crops grown specially for the purpose, would cost less than existing protein foods and about the same as estimates for yeast and *Chlorella*.

The discussion revealed two trends of thought on these new natural sources of foodstuffs. One was that orthodox agriculture would see us through this century and that these novel methods should await the development of new techniques. The other was that present drawbacks to these new foods are largely due to lack of information and that further investigation is most desirable. As Mr. Pirie said, all methods of increasing the world's food supply must be pushed ahead, for they are complementary rather than conflicting.

A. E. Bender

BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

ANNUAL REPORTS FOR 1951 AND 1952

THE recently received third annual report of the council of the British Gelatine and Glue Research Association (pp. 13; 1951) covers the year October 1950–September 1951, and the fourth (pp. 19; 1952) for that ending in September 1952. The former report records an increase of two in the full membership but no change in the staff. Two meetings of the Research Panel were well attended, the second, a symposium on the uses of gelatine and glue, providing a valuable opportunity for interchange of views between manufacturers and users. It was decided that at future meetings, in addition to papers of the type previously presented, accounts would be given of the research work of the Association; and the visit to the laboratories, which is a regular feature of Panel meetings, has proved a valuable link between the Association's staff and that of member firms. The fourth annual report records two additions to associate membership and one to full membership, as well as the appointment of an additional research officer for work on the physical and mechanical properties of gelatine and glue. The laboratories were officially opened on November 29, 1951, by Sir Robert Duncalfe, and two further meetings of the Research Panel are reported (see *Nature*, **169**, 24 (1952); **170**, 24 (1952); and **171**, 250 (1953)).

The reports of the Director of Research, included with each of these annual reports, indicate that during the next two or three years a substantial body of new knowledge concerning gelatine and glue will have been built up. Work on the purification of gelatin by ion exchange resins, for example, has shown that the ash content of gelatin is reduced from 2–3 per cent to 0·005 per cent by passing a 5 per cent solution through a mixed bed of the 'Amberlite' resins *IR*120 and *IRA*400. Even very high arsenic contents can thus be reduced below the limit prescribed for edible gelatine, and the method provides a ready means of determining isoelectric points. Detailed studies of the viscosity of very dilute solutions of gelatin have shown that the gelatin molecule is in a partly folded configuration at its isoelectric point, the equal and opposite charges along the molecule contributing to the folding. The technique developed by F. Sanger, in which fluorodinitrobenzene reacts with free amino groups of proteins, has been applied to the determination of end-groups in gelatin, and studies have also been made of the organic constituents of bone, while new methods have been developed for estimating the colour and clarity of gelatine and glue solutions and gels and for the accurate determination of arsenic in gelatine. A device has been constructed to facilitate accurate testing of jelly 'strength', and a detailed investigation of sampling errors in bacterial counts on powdered gelatine indicates that the variation is related to irregular distribution of bacteria in the gelatine, probably originating from the drying operation.

WORLD-WIDE CHANGES IN THE PHASE OF THE COSMIC-RAY SOLAR DAILY VARIATION

By T. THAMBYAHPILLAI and Dr. H. ELLIOT
Physical Laboratories, University of Manchester

MEASUREMENTS of the cosmic-ray diurnal variation at sea-level using directional counter arrays[1] have shown that the variation is at least in part due to an anisotropic distribution of the primary radiation entering the atmosphere. Since the variation is dependent on solar rather than sidereal time,

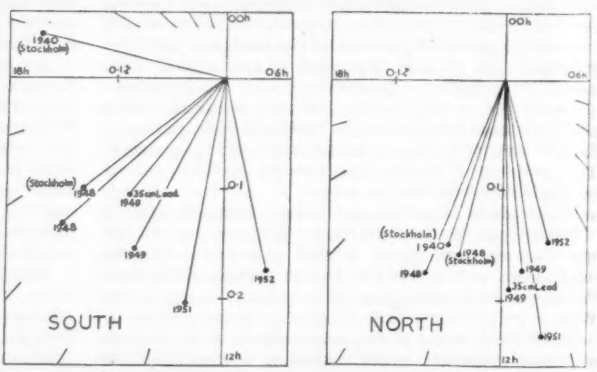


Fig. 1. Harmonic dials showing the first harmonics of the daily variation measured in Manchester and Stockholm using counter telescopes pointing south and north. All the measurements have been made using unshielded telescopes with the exception of one set of data for Manchester in 1949, when 35 cm. lead absorber was used

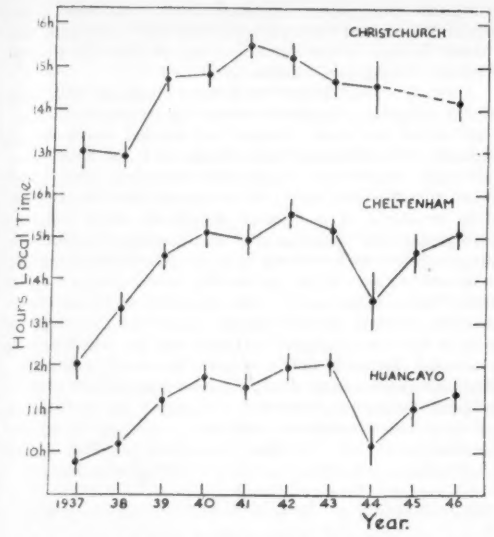


Fig. 2. Times of maximum for the first harmonics of the daily variation as measured by ionization chambers at Christchurch (lat. 43° S.), Cheltenham (39° N.) and Huancayo (12° S., 3,350 m. altitude)

the anisotropy is evidently caused in some way by the sun, and it is therefore important to ascertain whether there is any relation between the variation and the sunspot cycle. Earlier measurements in Manchester have therefore been repeated during the past two years, using the same apparatus as was used in 1948 and which consists of two counter telescopes with rather wide angles of acceptance, one pointing south and the other to the north and inclined at 45° to the vertical.

Fig. 1 shows the first harmonics of the annual mean daily variations plotted on a harmonic dial for 1951 and 1952, together with the earlier measurements in Stockholm and Manchester. It will be seen that there appears to have been a significant change in the daily variations between 1940 and the present time. The time of maximum for the south-pointing telescopes has fallen progressively earlier in the day from 1940 to 1952. There is a similar but much less marked trend for the north direction. The changes in amplitude over this period are not significant.

In view of these results, the ionization chamber data published by the Carnegie Institution of Washington[2], for Cheltenham (U.S.A.), Christchurch (N.Z.) and Huancayo (Peru), covering the period 1937–46 have also been examined. The first two stations are close to sea-level and at very nearly the same latitude (~40°) in the northern and southern hemispheres, respectively, whereas Huancayo is close to the equator and at an altitude of 3,350 m. The average diurnal variations at Christchurch and Cheltenham over the whole period 1937–46 have very nearly the same amplitude and phase, whereas that for Huancayo has the same amplitude but the time of maximum is 3·3 hr. earlier than at the other two stations. The phases of the annual mean daily variation at the three stations are shown plotted in Fig. 2 for each year. It will be seen that phase-changes have occurred during this period, and that the changes are roughly parallel at the three stations, indicating that they are not local in origin.

In Fig. 3 we have plotted all the data on the phase of the diurnal variation which are readily available. In all cases except the Hafelekar observations, a correction for barometric pressure only has been made. The Hafelekar observations, as published, had in addition been corrected for atmospheric temperature, and to this extent there is an uncertainty as to whether they are directly comparable with the observations from the other stations. Where directional counter measurements have been used, the mean variation for the two directions has been plotted. The Huancayo points have been displaced by a constant amount corresponding to 3·3 hr. to bring them into line with the other stations.

It will be seen that, although the points show a certain amount of scatter, there appears to have been a systematic change in phase over the years. The time of maximum fell progressively later from 1933 to 1942, and then the time of maximum has become gradually earlier from 1942 up to the present. It has been shown by Sekido and Kodama[3] that there is a relation between the phase of the diurnal variation and geomagnetic activity, the time of maximum falling earlier on days of high activity than on days which are undisturbed magnetically. It appears, however, that the changes in phase shown in Fig. 3 can at best be only partially accounted for in this way, since geomagnetic activity shows a predominantly 11-year cycle and the points in the

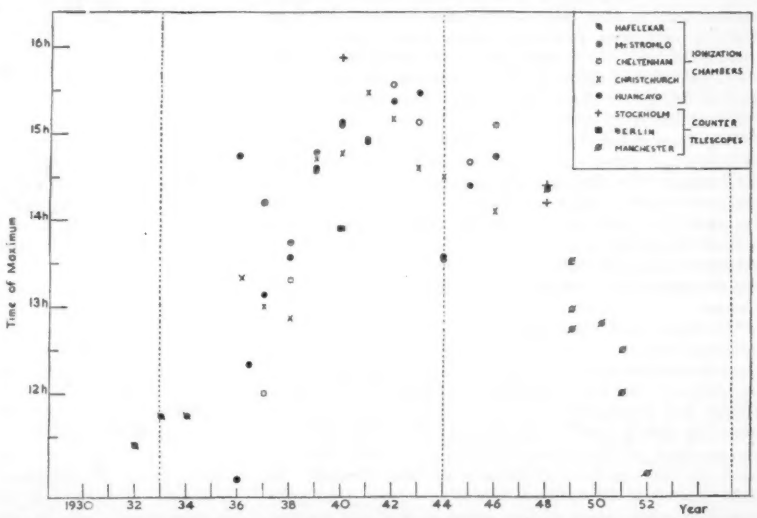


Fig. 3. Time of maximum of the first harmonics of the diurnal variation. The years of sunspot minimum are indicated by the broken lines

diagram do not show such a periodicity to any marked degree. The years of sunspot minimum are indicated by the broken lines in Fig. 3, where it will be seen that the minimum of 1933 corresponds to an early time of maximum for the daily variation and it appears likely that a similar state of affairs will hold for the next minimum (1955). The intervening minimum of 1944, however, corresponds to a late time of maximum. It is worthy of note that if the phase change is a periodic effect, the data in Fig. 3 could be fitted to a 22-year wave, which is, of course, the true period of the sunspot cycle. It is impossible at this stage to say with certainty whether or not the cosmic-ray data do show such a cycle, and many more years of systematic observation will be required to produce a conclusive result. There can be little doubt, however, that systematic changes in the phase of the diurnal variation do occur on a world-wide scale.

We are indebted to Dr. A. R. Hogg and Dr. D. I. Dawton for providing us with the results of their measurements on the daily variation. [April 23.

[1] Malmfors, K. G., *Ark. Mat. Astr. Fys.*, **32** A, No. 8 (1945). Elliot, H., and Dolbear, D. W. N., *J. Atmos. Terr. Phys.*, **1**, 205 (1951).
[2] Lange, I., and Forbush, S. E., Carnegie Inst. Wash., Pub. No. 175 (1948).
[3] Sekido, Y., and Kodama, M., Report of Ionosphere Research in Japan, **7**, No. 2 (1952).

FORMATION OF LABILE PHOSPHATE ESTERS BY IRRADIATION OF NUCLEIC ACIDS WITH X-RAYS IN AQUEOUS SYSTEMS

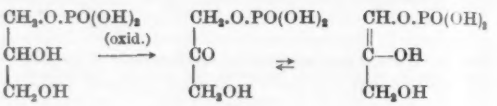
By Dr. GEORGE SCHOLES and Dr. JOSEPH WEISS

University of Durham, King's College, Newcastle upon Tyne

WHEREAS previously the action of X-rays on aqueous solutions of nucleic acids was considered to be essentially of a physical nature, studies carried out in this laboratory have established that definite chemical processes take place during the irradiation[1–4]. At lower doses of radiation, these chemical effects include the formation of ammonia and of inorganic phosphate; by using higher doses the formation of certain free bases and of titratable acid groups in addition could be shown. On the basis of these and other experimental findings, a tentative mechanism for the overall attack of the radicals produced by the radiation has been proposed[3,4]. The experiments seemed to suggest that hydrolysis of certain labile substances plays a part and that these substances include labile phosphate esters. However, the evidence then available was largely of an indirect nature.

We have now obtained some direct experimental evidence on this point, this being based on the fact that labile phosphate esters are more or less easily hydrolysed with the formation of inorganic phosphate. Blank and irradiated nucleate solutions were hydrolysed by dilute acid (under standard conditions) and the amount of liberated inorganic phosphate determined by the method of Berenblum and Chain[5]. In this way we have been able to show that, for example, with doses of the order of 9×10^4 r-units, in the presence of oxygen, the additional amounts of inorganic phosphate liberated from irradiated ribonucleic acid and deoxyribonucleic acid solutions are about fifteen times the amounts of free phosphate formed during the irradiation.

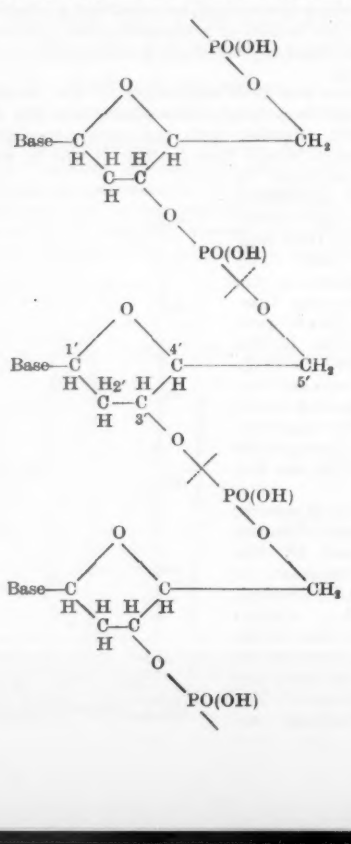
A study of the effects of X-rays on some relatively simple organic phosphate esters has shown that these can serve to some extent as model compounds. Among the substances investigated from this point of view were α- and β-glycerophosphate and 3-phosphoglyceric acid. Here again, further appreciable amounts of inorganic phosphate were released on subsequent hydrolysis of the irradiated solutions, although the acid-lability of these intermediate esters was rather lower than the lability of the esters formed from the nucleic acids. The interest in these three-carbon systems arises from the fact that the point of attack by the oxidative radicals can be predicted on chemical grounds with some degree of certainty. Such considerations would suggest that the formation of labile phosphate esters, for example, by irradiation of α-glycerophosphate solutions, results from an oxidative attack on the secondary alcohol group (β-position) according to the following reaction:



(I)

It is apparent that the acid lability of the irradiated solutions can be due here to the formation of compounds similar to (I).

In the case of the nucleic acids, we have already presented evidence that both the basic and pentose

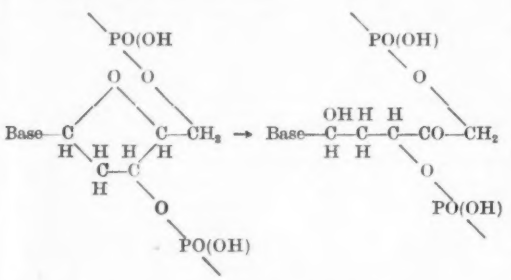


constituents are attacked by the radicals produced during irradiation, and it is possible that chemical changes in either of these components may increase the acid-lability of the resulting product.

The following discussion is limited to the labile esters which can arise by oxidation of the sugar part.

A small section of, for example, deoxyribonucleic acid can be represented as shown on p. 920. From this scheme it is obvious that the pentose —C(4′) atom occupies a unique position in this structure in that it is adjacent to two phosphate groups; oxidation at this centre, therefore, should have a pronounced labilizing effect. Furthermore, electrostatic interaction between the two phosphate groups may be an additional factor in their mutual labilization[6]. Subsequent hydrolysis of the labile phosphate bonds produced in this way will lead to a transverse fission of the polynucleotide chain with the production of both (3′)– and (5′)– (end) phosphate groups. When the (5′)– phosphate is already an end group, this should lead directly to the formation of inorganic phosphate.

If, on the other hand, there is an oxidative attack at C(3′) or C(5′), this will lead to an immediate scission of the corresponding phosphate bond without the intermediate formation of a labile ester. In deoxyribonucleic acid, neither oxidation at C(1′) nor at C(2′) should have any labilizing effect on the phosphate linkages. In ribonucleic acid, oxidation at C(2′), which here is a secondary alcohol group, could labilize the phosphate in the (3′)– position. On chemical grounds, however, it appears that C(4′) in both nucleic acids is rather vulnerable and a likely point of attack. Further, it is to be expected that oxidation at this position should also lead to an opening of the furanose ring:



Therefore, in addition to labilization of the adjacent phosphate bonds, the glycosidic linkage may also be considerably weakened, leading to the liberation of the base; the presence of free bases in irradiated nucleate solutions has already been observed previously[1].

These considerations may also be of some importance for the understanding of the mechanism of the 'after-effect' in deoxyribonucleic acid solutions[7,8], namely, the decrease in viscosity which continues for some time after cessation of irradiation. We have already stated[2,3] that some of the immediate loss of viscosity may be closely associated with a loss of 'hydrogen bonding', particularly through elimination of polar groups by the action of the radicals upon the constituent bases and possibly to some extent by elimination of phosphate end groups. Furthermore, an immediate scission of the polynucleotide chain should be brought about by oxidative attacks at the pentose C(3′) and C(5′), as pointed out above.

On the other hand, with regard to the post-irradiation effect, our results suggest that this may be due to the following reactions: (*a*) Transverse fission of the polynucleotide chain by hydrolysis of 'labile' phosphate esters as outlined above. This may be accompanied by loss of the corresponding base, and thus loss of some hydrogen bonds. (*b*) Attack at the double (ethylenic) bonds of the pyrimidines by the free radicals and (hydrolytic) liberation of the chemically changed base from the main polynucleotide chain.

It has been stated that the 'after-effect' in irradiated deoxyribonucleic acid solutions depends entirely upon the presence of oxygen[8,9]. However, this appears to be somewhat unlikely in view of the fact that there are also oxidizing (OH) radicals present under vacuum conditions. The effect of molecular oxygen has been studied in a number of other systems; for example, in the formation of acetaldehyde from alcohol[10], or of pyruvic acid from lactic acid[10] and from alanine[10], the ratios of the yields in the presence and absence of oxygen were found to be between 3 and 6, depending on the substance and on the experimental conditions. Therefore, the presence of oxygen during irradiation of the nucleic acids should only enhance the extent of oxidative attack upon the basic and pentose components.

In evacuated solutions, for example, the oxidation of a secondary alcohol group of the sugar would require a process similar to:

$$>CH(OH) \xrightarrow{OH} >\dot{C}(OH) \xrightarrow{OH} >C=O.$$

In the presence of oxygen, on the other hand, because of the process $H + O_2 \rightarrow HO_2$, the effective number of OH radicals may be increased by inhibiting the recombination of the primarily formed H and OH. Probably more important still, the yield may also be increased by reaction of the initially formed organic radicals with oxygen:

$$>\dot{C}(OH) \xrightarrow{O_2} >C(O-O\cdot)(OH) \rightarrow >C(O-OH)(OH) \rightarrow >C=O + H_2O,$$

that is, via a peroxide radical, which can eventually lead to the corresponding carbonyl compound.

All these experiments refer to *in vitro* conditions, and therefore any conclusions drawn from them with regard to the biological action of X-rays on nucleic acids are bound to be highly speculative. However, it is perhaps worth pointing out that there may be a connexion between the labile phosphate esters produced by the action of, for example, X-rays on nucleic acids and 'high-energy phosphate bonds'.

In general, observations on the lability of phosphate esters may also be of use in the elucidation of the point of attack of the free radicals.

Full details of this work will be published elsewhere.

[Jan. 6.

[1] Scholes, G., Stein, G., and Weiss, J., *Nature*, **164**, 709 (1949).
[2] Scholes, G., and Weiss, J., *Nature*, **166**, 640 (1950).
[3] Scholes, G., and Weiss, J., *Exp. Cell Research*, Supp. **2**, 219 (1952).
[4] Scholes, G., and Weiss, J., *Biochem. J.* (in the press).
[5] Berenblum, I., and Chain, E., *Biochem. J.*, **32**, 295 (1938).
[6] cf. Hill, T. L., and Morales, M. T., *J. Amer. Chem. Soc.*, **73**, 165 (1951).
[7] Taylor, B., Greenstein, J. P., and Hollaender, A., *Arch. Biochem.*, **16**, 19 (1948).
[8] Butler, J. A. V., and Conway, B. E., *J. Chem. Soc.*, 3418 (1950).
[9] Conway, B. E., and Butler, J. A. V., *J. Chem. Soc.*, 834 (1952).
[10] Johnson, G. R. A., Scholes, G., and Weiss, J. (in preparation).

POSITION OF HÆMS IN THE HÆMOGLOBIN MOLECULE

By Prof. D. KEILIN, F.R.S.
Molteno Institute, University of Cambridge

ONE of the problems which arises from the study of the mechanisms of oxygenation and oxidation reactions of hæmoglobin is the position occupied by the hæms in relation to the globin. The solution of this problem is of paramount importance for the proper understanding of the structure of hæmoglobin and of the interactions between the hæm and the protein in hæmoglobin, as well as in other natural hæmoprotein compounds.

The nomenclature of hæmoglobin and its derivatives which will be used in the present study comprises the classical terms which have previously been discussed and defined[1,2]. Although the term 'hæmoglobin' will be applied here in its widest sense, covering all hæmoprotein oxygen carriers, irrespective of their origin, but having protohæm as their prosthetic group[3], the position of hæms will be examined mainly in mammalian hæmoglobins (molecular weight 68,000) which have four hæms per molecule.

Imidazole Theory of Hæm-linked Groups in Hæmoglobin

It was undoubtedly the high histidine content of hæmoglobin that was primarily responsible for the view that the imidazole ring of this amino-acid forms the link between the hæm–iron and the globin. This view received some support from Langenbeck's[4] observation that hæmatin easily combines with different imidazoles, forming, especially with 4-methyl imidazole, very stable parahæmatin compounds. A more definite formulation of this view was made by Conant[5], who, in his Harvey Lectures, suggested that globin is linked to each hæm–iron through two imidazole rings of histidine residues of which one, being more easily displaced by oxygen than the other, forms the oxylabile group responsible for the well-known Bohr effect. However, it was Wyman and his co-workers[6,7,9] who made the first attempt to obtain more direct experimental evidence in support of this theory. The main results of this work were recently summarized by Wyman[8] in a masterly review of different aspects of hæmoprotein compounds. In the course of these investigations[6,7] they found that the heat of ionization of titratable groups between *p*H 5·5 and 8·5, calculated from the effect of temperature upon titration curves of hæmoglobin, was about 6,500 cal., which is very close to that of the imidazole group of histidine. Moreover, by comparing the effect of temperature on titration curves of hæmoglobin and oxyhæmoglobin, they were able to find that the heat of ionization of the oxylabile acid groups lies very close to that of the imidazole group of histidine. They concluded that the hæm–iron in hæmoglobin is linked with two imidazole groups of histidine residues, being, however, closer to one group than to the other. It is somewhat difficult to reconcile the result of this work, which indicates that the hæm–iron lies between two histidine residues, with one of the conclusions of Wyman's review[8], namely, that hæms in hæmoglobin lie attached to the surface of globin.

The imidazole theory also received support from magnetic susceptibility measurements carried out by Pauling and his co-workers, who were able to determine the nature of the bonds uniting the hæm–iron with the surrounding atoms and to offer the first structural interpretation of the hæm-linked groups in hæmoglobin and its derivatives[10].

Critical Examination of the Theory of the Embedded Position of Hæms

One of the important deductions which can be drawn from the imidazole theory of the hæm-linked groups, as formulated by Conant, Wyman and Pauling, is that the disk-like hæms lie within a fold or crevice of the globin. The concept of the embedded position of hæms was recently used by Pauling[11,12] and by St. George and Pauling[13] as a basis for an ingenious steric hindrance theory to account for the *S*-shaped oxygen equilibrium curve of hæmoglobin and for the hæm–hæm interaction. According to this theory, the enfolded positions of the four hæms between the layers of globin will limit the accessibility of oxygen to the hæm–iron. However, when an oxygen molecule reaches the first hæm–iron to form the oxygenated complex, the protein structure becomes somewhat loosened and thus makes the second hæm–iron more easily accessible to oxygen. With the formation of successive oxygenated complexes, the degree of hindrance to the penetration of oxygen progressively decreases, and this is reflected in the sigmoid curve of the reversible reaction between hæmoglobin and oxygen.

Since the steric hindrance theory is based upon the assumption that the four hæm groups of hæmoglobin are buried within the globin, St. George and Pauling (1951)[13] made an attempt to obtain more direct evidence in support of their view. For this purpose they investigated the reactions of free hæm and hæmoglobin with different alkyl isocyanides, such as the ethyl, isopropyl and tertiary butyl derivatives. They found that, whereas the nature and size of these isocyanides had no influence upon their affinities for free hæm, they had a marked effect upon their affinities for hæmoglobin. Thus, the affinity of hæmoglobin for isopropyl and tertiary butyl isocyanides was about 3 and 200 times lower respectively than its affinity for ethyl isocyanide. They ascribed this fall in the affinity to the increasing molecular sizes, and therefore to increasing difficulties of penetration of these isocyanides between the protein layers enfolding the four hæms.

However plausible and attractive may appear the theory of the embedded position of hæms in hæmoglobin and of the steric hindrance theory of hæm–hæm interaction, several important experimental results militate against them. Neither of these theories can therefore be accepted without a careful examination of these results, which can be summarized as follows.

(1) *Reactions of hæmoglobin with oxidizing and reducing agents.* It is well known that the divalent iron of hæmoglobin is oxidized by potassium ferricyanide ($K_3Fe(CN)_6$) and by methylene blue to the trivalent iron of methæmoglobin, and that the latter is reduced back by sodium dithionite ($Na_2S_2O_4$) to hæmoglobin. All these substances are much larger in size than a molecule of oxygen or of carbon monoxide. In fact, the reactions of hæmoglobin with ferricyanide and methylene blue have already been considered as an indication that the hæms lie attached to the surface of the globin[14]. Moreover, these reactions are of special interest considering that

neither ferricyanide nor dithionite ions can penetrate the cell membrane of the red blood corpuscles, facts which make possible the spectroscopic study of the mechanism and the kinetics of lysis, by different agents, of erythrocytes containing either hæmoglobin or methæmoglobin[15].

(2) *Formation of compounds with nitrosobenzene and imidazoles.* It has been shown that the divalent iron of free hæm and of hæmoglobin combines reversibly with nitrosobenzene forming spectroscopically well-defined complexes[16,17]. The same complexes are obtained when hæmatin and methæmoglobin are treated with phenyl hydroxylamine (C_6H_5NHOH). In this reaction phenyl hydroxylamine reduces free hæmatin and methæmoglobin to hæm and hæmoglobin respectively, while it is itself oxidized to nitrosobenzene (C_6H_5NO), which then combines with hæm and hæmoglobin[17].

It has also been shown that the trivalent iron of methæmoglobin combines reversibly with 4-methyl imidazole[18], forming a compound with an absorption spectrum of the parahæmatin type. Since the reactions of hæmoglobin and methæmoglobin with oxidizing and reducing substances consist in electron transfer between these substances and the hæm–iron, one cannot dismiss the possibility that such reactions take place indirectly through some groups belonging to the protein. Thus, the oxido-reduction reactions by themselves do not necessarily rule out the possibility of embedded hæms. However, the position is very different in the cases of nitrosobenzene and imidazole, which form co-ordination complexes with the iron of hæmoglobin and methæmoglobin respectively. To form such complexes the hæm–iron must be directly accessible to these substances.

Thus the view that hæms in hæmoglobin are embedded within a fold of globin which may hinder the penetration of oxygen molecules to the hæm–iron is difficult to reconcile with the facts that large polyvalent ions such as ferricyanide and dithionite or comparatively large molecules such as methylene blue, nitrosobenzene, phenyl hydroxylamine and imidazole can easily reach the iron of hæmoglobin or methæmoglobin and react or combine with it.

(3) *Reactivities of free hæmatin and of hæmatin bound to native protein.* The difference in the ability of a free hæmatin and of a hæmatin forming part of a native hæmoprotein to combine with certain substances cannot always be ascribed to the possible greater accessibility of the iron in the free hæmatin. In fact, the hæmatin of methæmoglobin may show a much greater reactivity towards certain substances of small molecular size than does free hæmatin. Thus, whereas methæmoglobin easily combines with azide[19], fluoride[20] and hydrosulphide[21] ions, to form well-defined compounds, free hæmatin forms no spectroscopically recognizable compounds with these substances. Moreover, the easily observed reactions of methæmoglobin, catalase and peroxidase with peroxides are in striking contrast to the great difficulties in demonstrating any of these reactions with free protohæmatin. Indeed, only urohæmatin has been found to form well-defined compounds with hydrogen peroxide and ethyl hydroperoxide[22]. On the other hand, of a variety of substances which combine with free hæmatin, only cyanide, nitric oxide and certain imidazoles combine with methæmoglobin, and of a still larger variety of substances which combine with free hæm[23], only cyanide, alkyl isocyanides, nitric oxide, carbon monoxide and nitrosobenzene combine with hæmoglobin.

(4) *Absorption spectra and nature of hæm complexes with different substances.* Free hæm and hæmatin combine with imidazoles to form compounds which are very similar in their structure and absorption spectra to the hæmochromogens and parahæmatins formed when hæm or hæmatin are combined with a great variety of nitrogenous substances such as pyridine, nicotine, piperidine, ammonia, glycine or denatured proteins. In all these compounds, the fifth and sixth co-ordination valencies of the hæm–iron are occupied by molecules of the corresponding nitrogenous substances[23]. Were the fifth and sixth valencies of iron in hæmoglobin and methæmoglobin occupied by the imidazole rings of histidine residues, their absorption spectra would be expected to resemble those of a hæmochromogen or a parahæmatin, which is not the case.

(5) *Magnetic properties of hæmoglobin and its derivatives.* The magnetic properties of hæmoglobin studied by Pauling and his co-workers enabled them to determine for the first time the nature of the bonds uniting the iron with the surrounding atoms in hæmoglobin and its derivatives. One of the interesting results obtained by Pauling and Coryell[24] is that oxygen which is paramagnetic with two unpaired electrons per molecule, on combining with hæmoglobin which is also paramagnetic with four unpaired electrons per hæm, forms diamagnetic oxyhæmoglobin which has zero magnetic moment. This implies that both oxygen and hæmoglobin on combining to form oxyhæmoglobin or on dissociating from the latter undergo profound changes in their electronic structure. Such behaviour of oxygen during its reaction with hæmoglobin closely resembles its behaviour when submitted to pressure[25,26]. It was shown a long time ago, although the facts have not since become widely known, that when molecular oxygen is compressed, two molecules of oxygen combine reversibly according to the equation: $2O_2 \rightleftharpoons O_4$; the amount of O_4 being proportional to the square of the pressure. The formation of O_4 can be followed by magnetic measurement, since O_2 is paramagnetic and has two unpaired electrons, whereas O_4 is diamagnetic and has no unpaired electrons. Here again the formation of O_4 and its dissociation to O_2 are accompanied by a very marked rearrangement in the electronic structure of the molecule. It is interesting to note that the formation of O_4 can also be followed spectroscopically, since O_4 shows sharp absorption bands not only in the ultra-violet but also in the visible region of the spectrum, and these can easily be observed in a steel tube fitted with glass windows designed to withstand high pressures. With an optical depth between the windows of about 60 cm. and a pressure of 120 atmospheres (the usual pressure of an oxygen gas cylinder) the four absorption bands in the visible region can easily be seen with a hand spectroscope. Moreover, it is O_4 that is responsible for the blue colour and the very sharp absorption bands at 631, 577, 532 and 478 mμ of liquid oxygen when it is examined in a non-silvered Dewar flask by means of a hand spectroscope[25,26]. In fact, the diamagnetic O_4 represents about 50 per cent by weight of liquid oxygen.

Magnetic measurements, like other methods applied to the study of hæmoglobin, have great merits as well as limitations. There is no doubt that it is the only method which can reveal the character of the bonding of the iron with the surrounding atoms in hæmoglobin as well as in its reversible and irreversible

derivatives. On the other hand, all this knowledge has not so far helped much towards an understanding of the fundamental properties of hæmoglobin, such as the very slow autoxidizability of its iron, its remarkable property of oxygenation, the peculiarities of the oxygen equilibrium curves, the Bohr effect, the nature of the hæm-binding protein groups, the position of the hæm in hæmoglobin, and many other properties, depending upon the integrity of the hæmoprotein molecule. Thus, for example, the Bohr effect cannot be ascribed[5,46], as was previously suggested[10], to changes in the nature of the bonds uniting the iron with the surrounding atoms from ionic of hæmoglobin to covalent of oxyhæmoglobin. In fact, the same changes in the nature of bonds take place in every hæmoprotein which can undergo oxygenation, yet myoglobin and certain hæmoglobins show no Bohr effect. On the other hand, the oxidation of hæmoglobin to methæmoglobin, which like oxygenation to oxyhæmoglobin shows a distinct Bohr effect, is not accompanied by changes in the nature of the iron bonding, which remains ionic.

Moreover, magnetic measurements do not differentiate between free hæm and hæmoglobin, each having four unpaired electrons, which indicates that the iron in both compounds is linked by ionic bonds. Neither do these measurements differentiate between oxyhæmoglobin and hæmochromogen which have no unpaired electrons, thus showing that the iron in both compounds is linked by covalent bonds. In other words, magnetic measurements do not reflect the remarkable differences between native hæmoglobin and those of its derivatives which have irreversibly lost their fundamental biological properties. The same limitation arises when the magnetic technique is applied to the study of other biologically active hæmoprotein compounds[27]. In this respect the study of magnetic properties of hæmoproteins fails to provide some of the information which is easily obtained from the biological and spectroscopic study of these compounds. In fact, by their absorption spectra, especially in the visible region of the spectrum, not only can all the derivatives of hæmoproteins be differentiated and identified but, in addition, any loss in specific biological activity can easily be recognized and estimated.

It appears that the results obtained from magnetic susceptibility measurements, which made possible the identification of the nature of the bonds uniting the iron with surrounding atoms, will not be made full use of until the structure of native globin, especially in relation to its biological specificity, is better understood.

(6) *Reconstruction of hæmoglobin from hæm and native globin.* The concept of the embedded hæms in hæmoglobin is difficult to reconcile with the comparative ease of its splitting into native globin and hæm and the reconstruction from these constituents of hæmoglobin which is capable of combining reversibly with molecular oxygen[28,29].

It is true that, under certain conditions such as those required for removal of hæms[30,31], treatment with strong urea solution[32-35], or high dilution[36,37], the hæmoglobin molecule or the liberated globin[30,31] may undergo a reversible dissociation into two equal parts. This phenomenon suggests that were the hæms embedded between layers of globin, their most likely position would be between the two halves of globin. However, the reversible dissociation of hæmoglobin into two halves is by no means a general phenomenon. It was recorded for hæmoglobins of horse, ox, cat and fœtal sheep, but so far has not been demonstrated for hæmoglobins of man, dog or adult sheep. Moreover, hæmoglobin reconstructed from free native globin and hæm differs from the original material in showing no Bohr effect and in having its oxygen equilibrium represented by a rectangular hyperbola[8]. The concept of steric hindrance cannot therefore be applied to the reaction of this hæmoglobin with oxygen even if the hæms in the reconstructed hæmoglobin are enfolded between the two halves of globin. On the other hand, hæmoglobins dissociated on dilution[38] or on treatment with urea[8] have an increased affinity for oxygen and retain the *S*-shaped oxygen equilibrium curve, although each half of the hæmoglobin molecule must be linked with two hæms now lying on the surface of the globin and therefore freely accessible to oxygen.

(7) *Hæmoglobin and myoglobin.* The view of the embedded position of hæms in hæmoglobin has not so far been extended to myoglobin. This is not surprising considering (*a*) that the size of the myoglobin molecule is only one-fourth that of mammalian blood hæmoglobin, (*b*) that the molecule does not undergo reversible dissociation into smaller units, and (*c*) that in the absence of a Bohr effect it is unnecessary to postulate the co-ordination of its iron with two imidazole groups of histidine one on each side of the disk-like hæm. On the other hand, if it is assumed that the four hæms of hæmoglobin are embedded between the layers of globin while the single hæm of myoglobin lies on the surface of the globin, the differences in the properties of these two pigments, especially the accessibilities of their iron to different reagents, would be greater than they really are. Myoglobin would also offer a more appropriate control than free hæm in the experiments with alkyl isocyanides carried out by St. George and Pauling[13]. That this is not the case is indicated by the reactions of methæmoglobin and metmyoglobin with different substances containing an imidazole group. Whereas both methæmoglobin and metmyoglobin combine reversibly with imidazole and 4(5)methyl imidazole, neither of these two pigments will react with histidine, histamine, carnosine, N-methyl benzimidazole or pilocarpine, which combine with the free hæm and hæmatin to form the corresponding hæmochromogen and parahæmatin compounds[22,39].

So far, all substances which are known to react with myoglobin and its reversible derivatives have been found also to react in the same way with hæmoglobin and its corresponding derivatives.

(8) *Evidence that the sixth co-ordination position around the iron in hæmoglobin and methæmoglobin is occupied by a molecule of water.* On drying hæmoglobin or methæmoglobin, their absorption spectra are replaced by those of hæmochromogen or parahæmatin respectively. On the reintroduction of water, these absorption spectra revert to their original states. Since in typical hæmochromogen and parahæmatin compounds both the fifth and the sixth covalent bonds of iron unite it to nitrogenous groups, the above experiments indicate that the sixth position around the iron in hæmoglobin and methæmoglobin is occupied by a molecule of water which, on drying, is replaced by a nitrogenous group of the protein[40-43].

This view is also supported by study of the absorption spectra of acid and alkaline methæmoglobin at low temperatures[25]. Thus, when a brown solution of acid methæmoglobin at *p*H 6 is cooled in liquid air, its absorption band in the red is intensified and slightly shifted towards the blue end of the spectrum.

On the other hand, when the red solution of alkaline methæmoglobin at *p*H 9, with absorption bands in the green, is cooled, it turns brown and its absorption spectrum changes to that of the acid form. Since cooling suppresses ionization[44], the above experiments indicate that the iron in acid methæmoglobin is linked to a molecule of water and that the formation of alkaline methæmoglobin involves the loss of a proton, as was originally suggested by Coryell, Stitt and Pauling[45], instead of the addition of a hydroxyl ion.

Position of the Four Hæms in Relation to Globin

As is shown above, study of the structure and properties of hæmoglobin and its derivatives supports neither the theory of the embedded position of hæms within the fold of the globin nor the steric hindrance theory of hæm–hæm interaction. On the contrary, much of the evidence suggests that the hæms are attached to the surface of the globin through linkages with both the iron and the porphyrin. Of the six co-ordination bonds of the iron atom, four lie in one plane and link it with the nitrogen atoms of the pyrrol nuclei, whereas the fifth and the sixth bonds, one on each side of the disk-like hæm, unite it to a nitrogenous group of the globin and to a molecule of water respectively. This molecule of water can be replaced (1) in hæmoglobin by a molecule of oxygen, carbon monoxide, nitric oxide, hydrogen cyanide, an alkyl isocyanide or nitrosobenzene, and (2) in methæmoglobin by a hydroxyl, cyanide, hydrosulphide, azide or fluoride ion, nitric oxide, hydrogen peroxide, an alkyl peroxide or an imidazole, to give rise to the well-defined derivatives of hæmoglobin and methæmoglobin.

Interaction between Hæms and Proteins in Hæmoproteins

Although the general weight of evidence invalidates the view that hæms in hæmoglobin are embedded between the layers of globin and that the hæm–iron is linked to the imidazole groups of two histidine residues lying one on either side of the flat hæm molecule, it does not dismiss the possibility that the imidazole rings may form the oxylabile groups responsible for the Bohr effect. Whatever may be the nature of these groups or their position, even if they are not directly linked with the hæm–iron, they may nevertheless be sufficiently influenced by the state of the hæm–iron to acquire the properties ascribed to the oxylabile groups. This is in general agreement with the view put forward by Wyman[46], namely, that the reactions of hæmoglobin with oxygen and carbon monoxide, as well as the Bohr effect, are intimately connected with marked changes in the structural configuration of the hæmoglobin molecule as a whole. In fact, the valency of the iron or its combination with different substances has a very profound effect upon the general protein properties of hæmoglobin such as solubility, crystalline structure, ease of crystallization and susceptibility to denaturation by different agents.

The converse is also true, namely, that the protein has a profound effect upon the properties of hæms linked to it. This is strikingly exemplified by many varieties of hæmoglobins which show marked differences in terms of affinities for oxygen and carbon monoxide, the shapes of the oxygen dissociation curves, the autoxidizability of the hæm–iron and the absorption spectra, especially in the visible region. That certain protein groups of globin which are not linked with, or are not even in close proximity to, the hæm may nevertheless affect its properties is clearly shown by the presence of the protein absorption band in the photodissociation spectrum of the carbon monoxide compound of myoglobin as demonstrated by Bücher and Kaspers[47]. Here the light energy absorbed at about 280 mμ by the two tyrosine and two tryptophane residues of globin is transmitted to, and used for, the photodissociation of the carbon monoxide–iron linkage.

That the protein portion of a molecule of a hæmoprotein cannot be considered as a colloidal carrier of hæmatin which merely enhances the activity of this prosthetic group is clearly illustrated by the fact that the same protohæmatin nucleus in combination with different native proteins may form highly specific hæmoprotein compounds such as hæmoglobin, catalase, peroxidase or a component of cytochrome which have several properties in common, but which show very striking differences both in the nature and in the magnitude of their biological activities.

[1] Keilin, D., Réunion Plénière de la Société de Biologie, *C.R. Soc. Biol.* (1927).
[2] Keilin, D., *Proc. Roy. Soc.*, B, **104**, 206 (1929).
[3] Keilin, D., and Hartree, E. F., *Nature*, **168**, 266 (1951).
[4] Langenbeck, W., *Berichte*, **65**, 1 (1932).
[5] Conant, J. B., Harvey Lectures, **28**, 159 (1932–33).
[6] German, B., and Wyman, J., *J. Biol. Chem.*, **117**, 533 (1937).
[7] Wyman, J., *J. Biol. Chem.*, **127**, 581 (1939).
[8] Wyman, J., "Adv. Protein Chem.", **4**, 407 (1948).
[9] Wyman, J., "Hæmoglobin; Symposium in memory of Sir Joseph Barcroft", 95 (Butterworth, London, 1949).
[10] Coryell, C. D., and Pauling, L., *J. Biol. Chem.*, **132**, 769 (1940).
[11] Pauling, L., "Hæmoglobin; Symposium in memory of Sir Joseph Barcroft", 57 (Butterworth, London, 1949).
[12] Pauling, L., 120th Meeting Amer. Chem. Soc., Div. Biol. Chem., 27c (1951).
[13] St. George, R. C. C., and Pauling, L., *Science*, **114**, 629 (1951).
[14] Granick, S., *J. Gen. Physiol.*, **25**, 571 (1942).
[15] Keilin, D., and Hartree, E. F., *Nature*, **157**, 210 (1946).
[16] Jung, F., *Naturwiss.*, **28**, 264 (1940).
[17] Keilin, D., and Hartree, E. F., *Nature*, **151**, 390 (1943).
[18] Russell, C. D., and Pauling, L., *Proc. U.S. Nat. Acad. Sci.*, **25**, 517 (1939).
[19] Keilin, D., *Proc. Roy. Soc.*, B, **121**, 165 (1936).
[20] Zeynek, R., *Z. physiol. Chem.*, **33**, 426 (1901).
[21] Keilin, D., *Proc. Roy. Soc.*, B, **113**, 393 (1933).
[22] Keilin, Joan, *Biochem. J.*, **51**, 443 (1952).
[23] Keilin, Joan, "Porphyrins, Metalloporphyrins and Hæmatin", dissertation, Cambridge (1950).
[24] Pauling, L., and Coryell, C. D., *Proc. U.S. Nat. Acad. Sci.*, **22**, 210 (1936).
[25] Keilin, D., and Hartree, E. F., *Nature*, **164**, 254 (1949).
[26] Keilin, D., and Hartree, E. F., *Nature*, **165**, 543 (1950).
[27] Hartree, E. F., Ann. Reports Chem. Soc. for 1946, **43**, 287 (1947).
[28] Hill, R., and Holden, N. F., *Biochem. J.*, **20**, 1326 (1926).
[29] Anson, M. L., and Mirsky, A. E., *J. Gen. Physiol.*, **9**, 169 (1925).
[30] Roche, J., Roche, A., Adair, G. S., and Adair, M. E., *Biochem. J.*, **26**, 1811 (1932).
[31] Gralén, N., *Biochem. J.*, **33**, 1907 (1939).
[32] Burk, N. F., and Greenberg, D. M., *J. Biol. Chem.*, **87**, 197 (1930).
[33] Burk, N. F., *J. Biol. Chem.*, **98**, 353 (1932).
[34] Steinhardt, J., *J. Biol. Chem.*, **123**, 543 (1938).
[35] Wu, H., and Yang, E. F., *Chinese J. Physiol.*, **6**, 51 (1932) (quoted by Steinhardt).
[36] Svedberg, T., and Pedersen, K. O., "The Ultracentrifuge" (Oxford: Clarendon Press, 1940).
[37] Tiselius, A., and Gross, D., *Kolloid Z.*, **66**, 11 (1934) (quoted by Svedberg and Pedersen).
[38] Hill, R., and Wolvekamp, H. P., *Proc. Roy. Soc.*, B, **120**, 484 (1936).
[39] Keilin, Joan (unpublished observations).
[40] Zeynek, R., *Nowiny Lekarskie Poznan*, **38**, 10 (1926).
[41] Haurowitz, F., "Hæmoglobin; Symposium in memory of Sir Joseph Barcroft", 53 (Butterworth, London, 1949).
[42] Haurowitz, F., *J. Biol. Chem.*, **193**, 443 (1951).
[43] Keilin, D., and Hartree, E. F., *Nature*, **170**, 161 (1952).
[44] Harned, H. S., and Embree, N. D., *J. Amer. Chem. Soc.*, **56**, 1050 (1934).
[45] Coryell, C. D., Stitt, F., and Pauling, L., *J. Amer. Chem. Soc.*, **59**, 633 (1937).
[46] Wyman, J., and Allen, D. W., *J. Polymer Sci.*, **7**, 499 (1951).
[47] Bücher, T., and Kaspers, J., *Biochim. Biophys. Acta*, **1**, 21 (1947)

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Effect of Magnet Inhomogeneities in the Strong-Focusing Synchrotron

The amplitude of transverse oscillations in a synchrotron due to gas scattering and spread at injection can be much reduced by using the strong-focusing principle[1]. In such a machine the oscillation amplitude is reduced in comparison with a conventional machine by a factor of order $0{\cdot}4\sqrt{n}$, where n is the field index $(-r_0/H_0.\mathrm{d}H/\mathrm{d}r)$. Oscillations induced by magnet misalignments are, however, larger in the strong-focusing machine by a factor of order $2\sqrt{n}$. This suggests that very accurate magnet assembly will be required.

As an example of the tolerances required, we first consider the effects of small random displacements of the sectors. The machine parameters used will be those of ref. 1, namely, $n \approx 3{,}600$; N, 240 sectors; orbit radius, 10^4 cm.; W, half-width of vacuum chamber, 1 in. Suppose now that one of the sectors is displaced radially or vertically by δ, then a simple calculation shows that an oscillation of order 5δ will be set up. If all the sectors are displaced by an amount the root mean square value of which around the orbit is Δ, the oscillation amplitude after one revolution will be of order $5\sqrt{240}\Delta \approx 75\Delta$. To ensure that the particle completes one revolution, therefore, we must have $75\Delta < 1$ in., that is, $\Delta < 0{\cdot}013$ in. This represents a fraction of $3{\cdot}6 \times 10^{-6}$ of the machine radius.

If this condition is met, it is important to inquire what happens on subsequent revolutions. A linear system will first be considered. This implies that n is independent of radius, and the various small centrifugal terms in the equations of motion are neglected. We continue to assume for the moment that alternate sectors are identical in form. The behaviour on subsequent revolutions depends essentially on the change of phase of the oscillation after one revolution. Subtracting integral multiples of 2π from this phase change, so that the remainder φ lies between $-\pi$ and $+\pi$, the oscillation amplitude fluctuates sinusoidally with an amplitude of about $2A/\varphi$ and a period of π/φ, where A is the oscillation amplitude after one revolution. If $\varphi = 0$ the system is resonant, and the oscillation amplitude builds up linearly by an amount A per revolution. In the general linear case where n varies slightly from one sector to the next, a further type of resonance can occur. We consider first the special case of a correctly aligned machine. Particles displaced from the equilibrium orbit will oscillate with an amplitude which increases in a roughly exponential manner if φ lies in a small region near 0, as in the resonances already considered, or near π (cf. Mathieu's equation). In the general case of a misaligned machine with n-variation, or other perturbations proportional to displacement or velocity, both linear and exponential types of resonance will occur. For the machine under consideration a change of n by 1·4 per cent varies φ by π, so that it must be controlled throughout the accelerating cycle to less than this if disaster is to be avoided.

The resonant build-up of oscillation can be limited by making the system non-linear, so that $\varphi(A)$ is now a function of amplitude. To study this amplitude limitation, two series of computations are being made on the Automatic Computing Engine at the National Physical Laboratory. The first of these is a study of the pendulum equation $\ddot{y} + (n/4)\sin y = 0$, with a constant impulse forcing term at fixed intervals corresponding to one revolution in the machine. The oscillation has been computed for various values of n, $\varphi(0)$ and impulse strength. For the second more realistic calculations, the equation $\ddot{y} \pm n \sin y = 0$ is used, the sign alternating between focusing and defocusing sectors. At the amplitudes considered, only the y and y^3 terms in the expansion of $\sin y$ are significant. The sectors are assumed to lie not on a perfect circle, but with their ends randomly distributed a certain distance from that circle, so that the computational problem is one of changing the $y = 0$ axis at each sector boundary. Particle orbits were calculated for one revolution through twenty-five randomly chosen arrangements of sectors to find the magnitude and variation in the amplitude due to misalignments, and for one typical arrangement the particle orbit was computed for up to sixty revolutions for various values of alignment accuracy.

The first calculation showed that A', where $\varphi(A') = \pi + \varphi(0)$, is an important parameter. For small impulses the system behaves like a linear system when φ is not near zero, and when φ is near zero the amplitude of oscillation varies periodically and is limited to about A'. For impulses such that after one revolution A is greater than about $A'/5$, the amplitude builds up erratically but indefinitely.

In the second series of computations the oscillation amplitude after one revolution was consistent with the simple statistical calculation given earlier. After many revolutions the behaviour was similar to that in the first series of computations, except that in the bounded solutions the repeating nature of the pattern of amplitude was not so clearly marked. Indeed, it is not certain that some of the apparently bounded solutions would not have diverged had the computation been carried over a larger number of revolutions. However, the limit of stability appeared to correspond to holding the sector tolerances to about $\pm$ 0·007 in. when the amount of non-linearity was adjusted so that $A' = W$.

We may conclude from these considerations that very great care must be paid to the magnet design in a strong focusing synchrotron. Elaborate methods of assembly will be necessary to get the particles once round the machine, and a very careful control of the field is essential to ensure that they do not hit the walls on later revolutions. Calculations so far suggest that, in principle, either a linear or non-linear system could be used, provided that the technological problems of constructing a sufficiently accurate magnet can be overcome. It must be emphasized, however, that there are many possible effects which we have not yet considered; notable among them are the coupling between vertical and horizontal oscillations, and the effect of non-linear inhomogeneities due to magnet profile inaccuracies and fringing fields.

We wish to thank Messrs. Bell, Goward and Walkinshaw for helpful discussions on the subject of this letter, and the Director of the National Physical Laboratory and members of the Mathematical Division for carrying out the computing programme. This work has been done in collaboration with the Proton Synchrotron Group of the European Council for Nuclear Research, and is published by

permission of the Director of the Atomic Energy Research Establishment.

Note added in proof. An extension of the first series of computations to the case where n varies slowly from one resonant value to the next while an orbit is being computed shows that the oscillation amplitude can become very large, even though for *fixed* n values in the same range it remains quite limited. Such a variation of n is likely to occur during saturation of the magnet iron.

J. B. Adams
M. G. N. Hine
J. D. Lawson

Atomic Energy Research Establishment,
Harwell, Berks.
March 9.

[1] Courant, E. D., Livingston, M. S., and Snyder, H. S., *Phys. Rev.*, **88**, 1190 (1952).

Beta-Spectrum of Arsenic-71

For the past few months, the 225-cm. cyclotron[1] and the electromagnetic isotope separator[2] of this Institute have been used as the basic tools for a series of investigations on radioactive isotopes. Radioactive samples produced by cyclotron bombardment have been separated in the isotope separator both for obtaining mass assignments and for providing sources for beta-spectroscopic work. Due to the high intensity and high energy of the beam available in this cyclotron (200–300 μamp. internal beam of 25-MeV. deuterons), very intense beta-sources of separated isotopes can be obtained. The present communication reports the preliminary results of such an investigation on arsenic-71. The work is still in progress and a more detailed paper will be published later.

Arsenic-71 of half-life 60 hr. is obtained among several other arsenic activities by bombarding germanium with deuterons. The isotope is reported to decay by positron emission (energy 0·6 MeV., absorption measurements) and K-capture[3]. Mei *et al.*[4] reported an electron line of energy 162 keV., which was ascribed to arsenic-71.

In the present investigation, arsenic-71 has been studied in the intermediate image beta-spectrometer[5]. Germanium metal (fused on to a copper plate by using a special soldering flux) was bombarded in the cyclotron with 25-MeV. deuterons (180 μamp.hr.). The active arsenic, together with some arsenic carrier, was then converted into arsenic hydride. The hydride gas was introduced into the ion source of the isotope separator and the ions of mass number 71 were collected on a thin aluminium foil (0·15 mgm./cm.^{2}). This foil was used as a beta-source in the spectrometer (resolution about 4·5 per cent; the Geiger–Müller counter window had a 'cut-off' of about 6 keV.).

The Kurie plot of the positron spectrum obtained gives an upper limit of 815 ± 20 keV. There is also an indication of the presence of a weak component having the end point at about 300 keV. In addition to Auger lines, we have found three conversion electron lines at 12·2, 22·0 and 164 keV. The former two are interpreted as the K and L lines of a gamma-ray of energy 23·3 ± 0·3 keV. The 164-keV. line is interpreted as arising from the K and L conversion of a gamma-ray of energy 175 keV. This line is probably identical with the 162-keV. line reported by Mei *et al.*[4].

The positron continuum and the 164-keV. electron line appeared to decay with a period which was in accord with the half-life found for arsenic-71 (see below).

In another separation of arsenic from germanium bombarded with deuterons, we collected ions of all mass numbers from 69 to 77 on an aluminium foil, which was then cut into narrow strips. In order to check the half-lives, the decay of the activity corresponding to each mass number was followed for several days. The strip corresponding to mass number 69 showed a comparatively weak activity with a half-life of about 35 hr., indicating the presence of some germanium-69 in the arsenic hydride gas. The half-life of arsenic-71 was found to be 65 ± 5 hr.

We wish to thank Messrs. W. Forsling and L. Holm for their help and advice regarding the chemical work.

Hugo Atterling
Sigvard Thulin

Nobel Institute for Physics,
Stockholm 50.
March 1.

[1] Atterling, H., and Lindström, G., *Nature*, **169**, 432 (1952).
[2] Bergström, I., Thulin, S., Svartholm, N., and Siegbahn, K., *Ark. f. Fysik*, **1**, 281 (1949).
[3] Nuclear Data, N.B.S. Circular 499.
[4] Mei, J. Y., Mitchell, A. C. G., and Huddleston, C. M., *Phys. Rev.*, **79**, 19 (1950).
[5] Slätis, H., and Siegbahn, K., *Ark. f. Fysik*, **1**, 339 (1949).

Creep of Copper under Stress Pulses

A general treatment of the problem of creep under intermittent, as distinct from alternating, stress has already been given[1] and applied to the creep of lead. The behaviour of copper conductors is of particular interest[2] because of the stress conditions to which they are subjected in alternators, and because of the important consequences of their failure. Experiments on high-conductivity copper have now been completed with the view of testing in more detail certain deductions which followed from the original analysis.

The character of the creep of the copper wires when tested under 730 kgm.cm.$^{-2}$ at 258° C. depended strongly on the previous anneal time. The instantaneous extension increases, and the creep-rate at any chosen time decreases, with increase in the time of anneal. Detailed discussion of this is outside the scope of this communication: it must suffice to say that all the specimens were annealed in the furnace for 17 hr. prior to the creep test, a time sufficient for the effect to attain equilibrium.

The original analysis indicated that the recovery effect could be formulated in terms of one parameter, n. This was the fraction of the material which recovered in full, during the off-load period, its original transient flow properties. It was shown that for lead the flow exactly fitted the Andrade β, or cubic, function[3] $\beta t^{1/3}$, where t is time.

The fraction n satisfied the relation

$$1/n = 1 + A(\tau/R)^{1/3}, \qquad (1)$$

where τ is time of load, R the recovery time (restricted to values less than some critical value R_c) and A a constant characteristic of the material. On this basis, approximations involving n can be developed for the case of regular repetitive stressing. In the case of copper under the test conditions quoted above, accurate cubic creep parabolas were again exhibited, with an instantaneous strain recovery on unloading

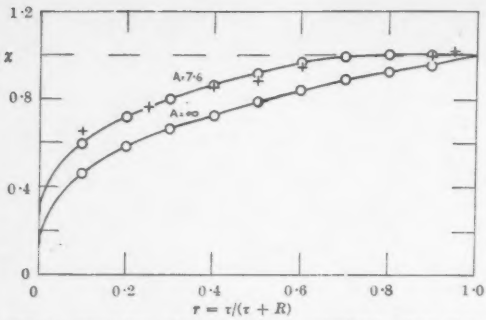


Fig. 1. Wave-form effect, showing the calculated values of χ (circles) for the two cases $A = \infty$ ('no effect') and $A = 7{\cdot}6$. The crosses are the experimental observations

of $\sim 0{\cdot}35$ mm. followed by a negligible creep recovery. No modification to the previous treatment was found to be necessary to take account of this property.

It can be shown that the ratio of the creep strain under a regular intermittent stress system to that achieved under an equal continuous stress, and for the same total test time, is given by:

$$\chi = [2{\cdot}845n(1 - 1/m^{1/3}) + 1]\, r^{1/3} \qquad (2)$$

if the transient creep function is a cubic one, m being the number of stress cycles and r the ratio $\tau/(\tau + R)$. Two effects are of importance.

(*a*) *Wave-form effect.* The results of experiments made with $m = 8$, over a total test time of 80 min., are summarized in Fig. 1. The lower curve shows the χ-ratio for a material which exhibits no recovery ($A = \infty$), and the upper curve shows the ratio for the case where $A = 7{\cdot}6$, the value deduced by fitting any section of one of the composite experimental curves. This calculated curve agrees very well with the experimental values obtained. It is worthy of note that χ can just exceed unity for this case ($m = 8$), and if a similar curve is calculated for $m = \infty$, then χ is found to exceed 1 over the large range of r-values, 0·3–1·0.

(*b*) *Frequency effect.* If $R < R_c$, equation (1) applies and n is dependent on the $\tau/(\tau + R)$ ratio only and not on the absolute values of these quantities. In this sense, then, there is no frequency effect, so long as the wave-form is unchanged. However, because of the occurrence of the term $(1 - 1/m^{1/3})$ in equation (2), an effect arises when $m^{1/3}$ is small. As $m^{1/3}$ increases to values much greater than unity, χ levels out sharply to an asymptote at $\chi = (2{\cdot}845n + 1)r^{1/3}$. This is demonstrated by the calculated curve in Fig. 2 for the case where $A = 7{\cdot}6$ and $r = 0{\cdot}5$. The experimental points, taken from results after 80 min. of test at different frequencies, are again in very good agreement and confirm the validity of the general treatment and the physical concepts on which this is based.

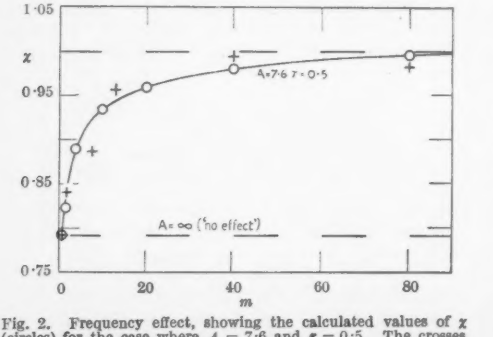


Fig. 2. Frequency effect, showing the calculated values of χ (circles) for the case where $A = 7{\cdot}6$ and $r = 0{\cdot}5$. The crosses are the experimental observations. If A equalled ∞ ('no effect'), the points would lie on the horizontal line $\chi = 0{\cdot}792$

A. J. Kennedy

Davy Faraday Laboratory,
Royal Institution,
21 Albemarle Street,
London, W.1. Nov. 12.

[1] Kennedy, A. J., *Proc. Roy. Soc.*, A, **213**, 492 (1952).
[2] Benson, N. D., McKeown, J., and Mends, D. N., *J. Inst. Met.*, **80**, 131 (1951).
[3] Andrade, E. N. da C., *Proc. Roy. Soc.*, A, **84**, 1 (1910).

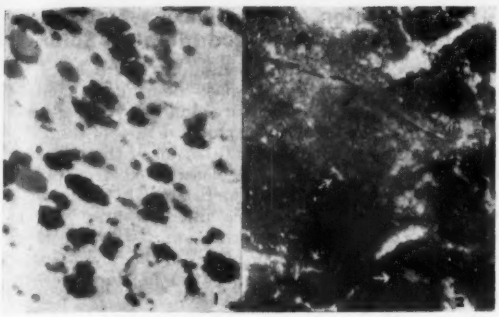
Microscopical Identification of the Constituents of Coal Dust

In connexion with the work of the Pneumoconiosis Research Unit into the cause of pneumoconiosis, attention has been devoted to the problem of identifying and estimating the quantity of respirable constituents of the dusts found dispersed in the air in collieries. It was considered that a technique based on the plastic behaviour of fine particles as observed by me[1] and later confirmed by Bangham and Berkowitz[2] might be evolved.

A number of different types of crushing lenses have been made, and with them it is possible to crush suitably prepared samples of colliery dusts while watching them under the microscope. Coal substance under the conditions used becomes plastic and spreads. Minerals either spread, or shatter to smaller fragments, of micron size or less. They are colourless and thus easily distinguishable from the coal. Most coals in thin sections are highly coloured and the various ingredients readily recognized, the exceptions being those of high-rank, such as anthracites, which are practically opaque even in the thinnest sections.

The crushing technique for the estimation of some of the ingredients forming coal has now been improved so as to include the high-rank anthracites. The accompanying photographs (× 150) show two high-rank anthracites during crushing. Fig. 1 depicts particulate coal. The oval dark patches of the photograph are translucent and appear reddish-brown under the microscope; they are vitrinite. The lighter grey oval patches are exinite and are bright yellow under the microscope. (The correspondence between colour and constituent has been established in lower-rank coals and it seems reasonable to apply it to higher-rank coals.) The large rather irregular oval white patch is mineral matter. Fig. 2 is an almost continuous sheet of another anthracite formed by the coalescence of a deposit of fine particles in which irregular light-grey flecks (arrowed) represent the yellow exinite. Most of the photograph shows shades of darker grey which represent the vitrinite ingredients and is reddish-brown under the microscope. The clear patches in both photographs are uninterrupted light.

There is a striking difference in the amount of exinite portion of these two anthracites. It is interesting to see that the 'flash' of the yellow exinite as a contrast to the reddish-brown of the vitrinite is as apparent in the anthracite as in the lower-rank coals, although the carbon content is so much higher. It is hoped to investigate whether this phenomenon occurs in anthracites formed by the influence of heat.



Because of the persistence of different colours of the coal ingredients in the anthracites when treated this way, a quantitative estimation of the vitrinite, fusinite, exinite fraction of the coal of all colliery dusts should now be possible. The mineral fraction is readily estimated by the areas of translucency, and it is hoped, at least, to separate the minerals into several groups by a further development of the method based on interference phenomena.

R. G. H. B. Boddy
Medical Research Council
Pneumoconiosis Research Unit (S. Wales),
Llandough Hospital,
Penarth, Glam.
Nov. 3.

[1] Boddy, R. G. H. B., *Nature*, **151**, 54 (1943); *Fuel*, **22**, 56 (1943); "Ultra-fine Structure of Coals and Coke" (Brit. Coal Util. Res. Assoc., 1943).
[2] Bangham and Berkowitz, *Research*, 86 (1947).

Alleged Optical Activity in Crystal Class *m*

Optical activity is theoretically possible in crystals belonging to the non-enantiomorphous classes *m*, *mm*2, $\bar{4}$ and $\bar{4}2m$; but only one substance has ever been cited as an example[1]. This is the dimer of the β-form of methyl mesityl oxide oxalate $(C_9H_{12}O_4)_2$, which was assigned by Sommerfeldt[2] to class *m* on the basis of morphological measurements.

Crystals corresponding exactly with those described by Sommerfeldt have been examined with X-rays and found to have the uniquely identifiable space group $P2_1/c$ with $a = 9{\cdot}15 \pm 3$ A., $b = 11{\cdot}56 \pm 5$ A., $c = 18{\cdot}02 \pm 5$ A., $\beta = 96° 12' \pm 20'$; $d_{obs.} = 1{\cdot}290$ gm.cm.$^{-3}$, $d_{calc.} = 1{\cdot}289 \pm 10$ gm.cm.$^{-3}$ for four molecules per unit cell. Sommerfeldt's axes are related to these by the transformation $10\bar{2}/010/\bar{1}02$. Polysynthetic twinning is prevalent, though the polarizing microscope gives no hint of this: the twins have $(10\bar{2})$ and [010] in common and the twinned reciprocal lattice approximates closely to Laue symmetry *mmm*. The habit of the single crystals resembles that of the crystals of the corresponding ethyl ester, which Sommerfeldt assigned to class $2/m$. (The lattice of the ethyl ester apparently does not so easily permit analogous polysynthetic twinning.) The assignment of the methyl ester to class *m* is therefore erroneous though perhaps understandable.

Sommerfeldt's evidence for optical activity, which was only qualitative, may now be rejected for two reasons: (*a*) the centrosymmetry of the space group; and (*b*) his observations could, as Voigt[3] pointed out, be the result of twinning, or merely a consequence of increasing the illumination and so forcing a perceptible amount of light through the crossed nicols. This example may therefore be rejected, as it neither exhibits optical activity nor is in class *m*.

The absence of any example of optical activity in classes *m*, *mm*2, $\bar{4}$ and $\bar{4}2m$ may suggest some development of the existing theory or, more probably, reflects the considerable experimental difficulties of measuring optical activity in the presence of birefringence, and the decline of interest in this subject during recent years. A large number of substances have by now been reliably assigned to these classes, so that an intensive search among suitable representatives seems desirable.

A full account of the crystallography of the monomeric and dimeric forms, and a detailed discussion of Sommerfeldt's interpretation of the optical observations, will be published elsewhere.

D. Rogers
Physics Department,
University College,
Cardiff. Oct. 31.

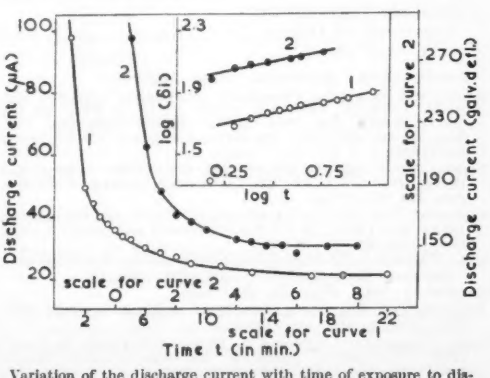
[1] Wooster, W. A., "Crystal Physics", 154 (Camb. Univ. Press, 1938).
[2] Sommerfeldt, E., "Neues Jahrbuch für Mineralogie", **1**, 58 (1908).
[3] Voigt, W., *Phys. Z.*, **7**, 267 (1906).

Langmuir Adsorption as a Determinant of Conductivity in a Low-frequency Electric Discharge

The marked influence of sorption of electronegative gases on photo- and thermo-electric currents in a number of systems is well known[1]. We have now investigated the significance of Langmuir adsorption or chemi-sorption, chiefly occurring under discharge[2], in determining the conductivity of a gas excited at reduced pressures by low-frequency potentials.

Siemens-type ozonizers made of soft soda glass and degassed for the removal of pre-adsorbed gases by heating for 15 hr. at 200° C. [3] were employed; they were filled with iodine or water vapour at a desired pressure and excited by a 50-cycle potential. The root-mean-square value of the current *i* was measured by a microammeter or a galvanometer actuated by a crystal detector, vacuo-junction, etc.; and the nature of the current was studied by a cathode-ray oscillograph. The accompanying graph gives a typical series of results.

With the time of exposure to discharge due to a fixed applied potential sufficient to cause a self-



Variation of the discharge current with time of exposure to discharge. Curve (1), in water; curve (2), in iodine vapour

maintained discharge, i (and the associated high-frequency pulses observed on the cathode-ray tube) decreased rapidly and attained saturation within an appreciably short time interval (curves 1 and 2). It is suggested that sorption under discharge was exceedingly rapid[2], and it was attributed to the increased proportion, and accessibility to the surface containing free Langmuir sites[4], of gas particles with enhanced 'activation' energy[5]. Bangham[6] suggested that the amount (x) of gas adsorbed up to time t follows a power–time law, $x = kt^{1/m}$. Our results also showed that the decrease (δi) in the conductivity up to time t obeys a similar relationship (cf. curves 1 and 2 of inset graph: log δi is sensibly a linear function of log t as required by an equation $\delta i = k't^{1/m}$ analogous to Bangham's equation.

Calculations showed that the decrease of pressure due to uptake of gas particles by the known available surface area was inappreciable (for example, less than 0·01 mm. mercury when the initial pressure employed was 32·1 mm. of water vapour); in fact, theoretical considerations on the electrical discharge in gases[7] indicate that, for a fixed applied field, a reduction in gas pressure increases i, as actually observed[8]. The decrease of the conductivity (see graph) and its high-frequency pulses, with sorption on glass of iodine or water, are in agreement with the general decrease of photo- and thermo-electric currents by adsorbed electro-negative gases[1]; this suggests that atoms adsorbed on Langmuir sites increase the work function of the surface or inhibit the release from the (instantaneous) cathode of secondary electrons, the number of which controls the current i. If S stands for a Langmuir site on clean glass surface, sorption of an electronegative atom such as iodine and its influence on electron liberation can be represented as:

$$S + I^* \rightarrow S - I;\ S - I + e \rightarrow S - I^-.$$

This indicates that atoms when adsorbed on glass retain their electronegativity; a view which is contrary to the current view that in Langmuir adsorption atoms adhere by sharing an electron with an alkali atom in the glass.

The work reported here was carried out in the Chemical Laboratories, Banaras Hindu University, Banaras.

A. P. Saxena

Holkar College,
Indore.

M. G. Bhatawdekar*
N. A. Ramaiah

Chemistry Department,
University of Delhi.
Oct. 28.

* Present address: Maharajah's College, Jaipur.

[1] Hughes and DuBridge, "Photoelectric Phenomena" (McGraw-Hill, 1932). Langmuir, *Phys. Rev.*, **2**, 450 (1913); *Z. Phys.*, **15**, 520 (1914). Debye, *Ann. Phys.*, **33**, 441 (1910). Richardson, *Phil. Mag.*, **23**, 286, 615 (1912). Basworth, *J. Roy. Soc. N.S.W.*, **79**, 53, 166 (1915).

[2] Taylor, *Nature*, **121**, 708 (1928); **122**, 347 (1928). Willows and George, *Proc. Phys. Soc.*, **28**, 124 (1916). Johnson, *Proc. Roy. Soc.*, **123**, 603 (1923).

[3] Sherewood, *Phys. Rev.*, (2), **12**, 448 (1918). Harries and Schumacher, *Indust. Eng. Chem.*, **15**, 176 (1923). Razouk and Salem, *J. Phys. Coll. Chem.*, **52**, 1208 (1948).

[4] Miller, "Adsorption of Gases on Solids" (Cambridge, 1949). McBain, "Sorption of Gases by Solids" (Routledge, 1939).

[5] Ramaiah, *J. Chim. Phys.*, **49**, 328 (1952).

[6] Bangham, *Phil. Mag.*, (7), **5**, 737 (1928). Bangham and Burt, *Proc. Roy. Soc.*, A, **105**, 481 (1924).

[7] Loeb, "Fundamental Processes in Electrical Discharge in Gases" (John Wiley, 1939). Townsend, "Electrons in Gases" (Hutchinson's Sci. and Tech. Publications, 1947).

[8] Ramaiah, *J. Sci. Res.*, **1**, 110 (1950–51).

Determination of the Relative Electrode Potential of an Uncharged Metal in Solution

A rectangular frame pendulum (Herbert type), oscillating on a spherical glass bearing in contact with a metal surface and surrounded by an electrolytic solution, is known to exhibit a rate of damping which is roughly a parabolic function of the potential of the metal surface[1] (cf. the classical electrocapillary curve). Rehbinder[1] (see also Rozhanski[2]) envisaged the formation of "reversible micro-fissures" in the metal surface under deformation: the electrical double layer penetrated the orifice of the micro-fissure, reducing cohesion, and hence the hardness, of the metal.

Using a Herbert-type pendulum, a relation between $\frac{1}{a}\frac{da}{dt}$ (where a is initial amplitude of oscillation of pendulum and t is time) and potential was obtained on a zinc surface in N hydrochloric acid with a maximum coinciding with that previously reported. The pendulum was then replaced by a 136° Diamond Pyramid (Vickers) hardness tester, employing a load of 1 kgm. (the same weight as the pendulum), and the same solution and potential variation conditions. No variation of hardness with potential was observed: Rehbinder's explanation hence appears invalid.

The maxima of the $\frac{1}{a}\frac{da}{dt}$/potential relations were determined in $N/10$ and $N/100$ aqueous solutions of hydrochloric acid for zinc, lead, cadmium, copper and nickel. These 'decay maxima' lie upon the linear relation which exists between the potentials of the electrocapillary maxima[3–5] of mercury, gallium and platinum, and the work functions of these metals. Further, determination of the potential of the decay maxima on an amalgamated copper surface in (not highly purified) $M/10$ hydrochloric acid showed this to be $-0{\cdot}19 \pm 0{\cdot}03$ V. on the hydrogen scale, whereas in the absence of specific adsorption the potential of the electrocapillary maximum at a mercury-solution interface is about $-0{\cdot}22$ V. (That the potential of the electrocapillary maximum on amalgamated copper can be taken as closely approximating to that on mercury under the same solution conditions follows, for example, from the equivalence of the overpotential[6] results on mercury and amalgamated copper at the same current densities.) These facts strongly suggest that the potential of the decay maximum can be identified with that of the electrocapillary maximum (charge-free surface). An experimentally easy method of determining the potential of a charge-free surface at a solid metal-solution interface is therefore available. Previous indication of this was by a comparison of pendulum maxima with electrocapillary maxima obtained by measurements on molten zinc in a eutectic of potassium and lithium chlorides[7]; but the invalidity of the conversion of potential scales from that used in the molten, to that of the aqueous, system makes this comparison useless.

It can be shown that $\frac{1}{a}\frac{da}{dt} \simeq K\mu$, where K is a constant and μ is the coefficient of friction of glass or metal. An explanation of the phenomenon reported therefore rests upon understanding the dependence of friction on interfacial potential. An appreciable layer (continuous or broken by 'welds' between metal and bearing) of electrolytic solution

must exist between the metal and the pendulum bearing. Except at the point of zero charge, excess ions of one sign exist in the double layer and mutually repel each other, thus resisting compression increasingly with increasing departure from the potential of zero charge. As the charge on the metal increases, the mean distance from the bearing surface to metal surface increases, thus reducing the attractive force between the surfaces (or, effectively, the load of one surface on the other), and so diminishing the friction. Hence, μ is greatest when zero charge exists on the metal surface, and the potential at this point thus coincides with the $\frac{1}{a}\frac{da}{dt}$-potential maximum.

It was suggested by Barker[8] that the chief features of the friction-potential relations of platinum are due to the adsorption of oxygen and hydrogen. Bowden and Young[9] later advanced a dual explanation in which effects due to the electrical double-layer are superimposed on effects due to adsorbed gases. That adsorbed gases are not always necessary to explain the effects of potential on friction is shown by the results for amalgamated copper where, for the potential range studied, adsorbed oxygen is absent and the adsorption of hydrogen is very small.

J. O'M. Bockris
R. Parry-Jones
Department of Inorganic and Physical Chemistry,
Imperial College of Science and Technology,
London, S.W.7.
Nov. 11.

[1] Rehbinder and Wenstrom, *Acta Physicochim.*, **19**, 36 (1944); *Doklady Akad. Nauk.*, **68**, 329 (1949).
[2] Rozhanski, *Zhurn. Tekn. Fis.*, **19**, 1056 (1949).
[3] Grahame, Technical Report, U.S. Office of Naval Research, **2**, 19 (1950).
[4] Frumkin and Gorodetskaya, *Z. phys. Chem.*, **136**, 215 (1928).
[5] Gorodetskaya and Kabanov, *Phys. Z. Soujet.*, **5**, 418 (1934).
[6] Bockris and Azzam, *Trans. Farad. Soc.*, **48**, 145 (1952).
[7] Karpachev and Stromberg, *Acta Physicochim.*, **12**, 523 (1940).
[8] Barker, Dissertation, Cambridge (1947).
[9] Bowden and Young, *Research*, **3**, 235 (1950).

Mechanism of Electropolishing

Electropolishing in molten salts. I have found that gold, platinum and palladium may be anodically polished using pure ('Analar') molten potassium chloride or sodium chloride as electrolyte. With palladium electrodes of about 1 cm.^{2} area and 2 cm. apart at about 950° C., etching occurred at low current-density, but gave place to polishing at about 1 amp./cm.^{2} (calculated on the inner faces only) and 3 volts potential difference. For gold at 970° C. and platinum at 1,020° C., using a 3-cm. diameter nickel crucible as cathode, there appeared to be no clearly defined lower limit to the polishing conditions, but polishing was observed at and above 0·15 amp./cm. and a potential difference of 1·5 volts. Palladium was also polished in an enclosed system with hydrogen bubbling vigorously through the electrolyte around the anode.

'Baser' metals than the three mentioned (for example, iron and copper) give less brilliant results, probably because they are attacked while cooling by the contents of the adhering electrolyte.

Conditions at polishing and etching anodic surfaces. The adsorptive conditions at polishing and etching copper surfaces have been directly compared in an arrangement consisting of a vertical cathode (1 cm. square) and a horizontal anode (1 cm. × 5 cm.) with its long axis normal to the cathode and its tip 1 cm. from the centre. In 50/50 v/v phosphoric acid, it was possible to adjust the voltage (*c.* 1·2 V.) so as to produce three differing anodic bands simultaneously: (*a*) polish for 1 cm. from the tip; (*b*) an intermediate area; (*c*) etch on the remainder. When about 1 per cent of 'saturated' mercuric nitrate solution was included in the electrolyte, amalgamation took place on all except the polishing surface (*a*). Similarly, on anodes which had narrow, lightly amalgamated lines drawn along their lengths, mercury was removed in the polishing region but the lines broadened in the etch region. Bands similar to (*a*), (*b*) and (*c*) were produced in an electrolyte of 1 *M* $CuSO_4$ (at *c.* 3 V.) and behaved correspondingly towards mercuric ions, although the area (*a*) was matt and after a few minutes became covered with a dark brown deposit. In both phosphoric acid and copper sulphate, mercury droplets sprayed over the anode would not adhere readily to the area (*a*).

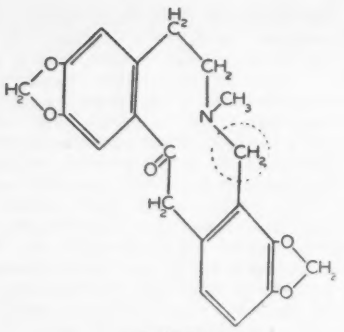
The experiments in molten electrolytes show clearly that electropolishing cannot be explained by postulating layers of oxide, hydroxide, etc., on the anode[1], for in this case the substances corresponding to oxides would be chlorides of the metals concerned, and under the conditions of the experiments the lattices of the chlorides of gold, platinum and palladium could not exist. The possibility of oxide films due to dissolved oxygen is ruled out by the experiment in hydrogen and by the observation that in all cases polishing could be obtained at temperatures well above those at which oxide could survive. Similarly, it is concluded from the behaviour of copper anodes towards mercuric ions in aqueous solutions that the non-adherence of mercury droplets to a polishing surface, reported by Hoar and Farthing[2], is due not to oxide films but to failure to establish a contact-adsorbed film of mercury at the relatively high current-density required for polishing. Further, since the etch-forms and growth-forms of metal crystals are controlled by adsorption[3], the observations indicate that at high current-density etch is inhibited because the formation of regularly adsorbed layers is prevented. Polishing should then follow automatically, since the electric field will be highest at projections. The matt surface of type (*a*) obtained in copper sulphate electrolyte is believed to be due to the formation of solid by-products in contact with the metal, since it resembles that of a copper single crystal which has been attacked by iodine vapour with the formation of solid cuprous iodide.

P. R. Rowland
Guy's Hospital Medical School,
London, S.E.1.
Sept. 20.

[1] Hoar, T. P., and Mowat, J. A. S., *Nature*, **165**, 64 (1950).
[2] Hoar, T. P., and Farthing, T. W., *Nature*, **169**, 324 (1952).
[3] Erdey-Gruz, T., *Z. phys. Chem.*, A, **172**, 157 (1935). Tamman, G., and Sartorius, F., *Z. anorg. allgem. Chem.*, **175**, 97 (1928). Gwathmey, A. T., and Benton, A. F., *J. Phys. Chem.*, **44**, 35 (1940). Rowland, P. R., *Nature*, **164**, 1091 (1949).

Origin of the Methylenedioxy Groups of the Alkaloid Protopine

There is a rapidly increasing body of evidence in the literature that all biological methylation processes, as well as many other 'single-carbon' biological syntheses, have a common pattern. It has been shown that the N-methyl groups of the alkaloids



Protopine

hordenine[1,2] and nicotine[3], and the N- and O-methyl groups of the alkaloid ricinine[4], have the same origin as the labile methyl groups in animal metabolism. Similarly, the O-methyl groups of barley lignin have been shown to fit this same pattern[5]. We have recently extended these observations to the methylenedioxy and N-methyl groups of the alkaloid protopine.

The plants used in these experiments were *Dicentra* hybrids (*Dicentra eximia* (Ker.-Gawl) Torr. × *Dicentra oregana* (Eastwood)), which we have shown produce considerable amounts of protopine under the conditions of these experiments. Three rapidly growing young hybrids were fed, respectively, carbon-14 methyl-labelled L-methionine, carbon-14 methyl-labelled choline and carbon-14-labelled sodium formate. The labelled materials were administered dissolved in the liquid culture solution[6] in which the plants were growing. At the end of a one-week growth period in contact with the labelled materials, all three plants had translocated activity to their topmost leaves and were removed from the solutions and dried in an oven at 110°. The dried plants were extracted with methanol in a Soxhlet extractor, and carrier protopine (500 mgm. per plant) was added to each extract. The protopine from each extract was isolated according to the procedure of Manske[7] and purified to constant specific activity by recrystallization of the free base and its nitrate salt from methanol. The specific activity of the N-methyl group was determined by degrading a portion of the alkaloid according to the methylimino determination of Pregl[8] and trapping the liberated methyl iodide in trimethyl amine. The tetramethylammonium ion was counted as its reineckate. The specific activity of the methylenedioxy groups was obtained by the hydrolysis of a separate portion of the alkaloid with 20 per cent sulphuric acid followed by the isolation and counting of the liberated formaldehyde as its dimedone derivative. The results of these determinations are shown in the accompanying table.

Metabolite administered			Specific activity (c.p.m. per m*M.*)		
	Weight (mgm.)	Activity (c.p.m.)	Protopine	Methylenedioxy group	N-methyl group
L-Methionine	82	$1{\cdot}2\times10^7$	$8{\cdot}8\pm0{\cdot}1\times10^3$	$1{\cdot}5\pm0{\cdot}1\times10^3$	$1{\cdot}9\pm0{\cdot}1\times10^3$
Sodium formate	10	$5{\cdot}0\times10^7$	$1{\cdot}3\pm0{\cdot}1\times10^3$		
Choline chloride	60	$3{\cdot}0\times10^7$	0		

It is seen that methionine methyl serves as a precursor of both the methylenedioxy and N-methyl groups of the alkaloid. Formate also contributes activity to the molecule, although to a considerably less extent than methionine. Formate serves as a precursor of labile methyl in the barley and tobacco plants[2,3], but it could not be shown with certainty that it was a precursor in the present case. The radioactivity in the alkaloid from the formate experiment was so low that significant specific activities for the degradation products could not be obtained. Nevertheless, the results indicate that the methylenedioxy groups arise from the oxidation of an O-methyl group followed by ring closure on an adjacent hydroxyl rather than a formylation followed by reduction and ring closure. If the reverse were true, one would expect the alkaloid from the formate run to be labelled to at least as great an extent as the alkaloid from the methionine run. This follows from the fact that the level of activity fed in the formate experiment was four times that in the methionine experiment. If formate was a more direct precursor of the methylenedioxy groups than was methionine methyl, this high activity which was fed, coupled with the fact that the methylenedioxy groups contribute one-third of the total activity in the methionine run, would lead one to expect a higher level of activity in the formate experiment.

The fact that choline methyl does not contribute activity is not surprising. It has been previously shown, in the case of both barley and *Ricinus* plants, that choline methyl contributes neither to the 'labile methyl' nor 'formate' pools of these plants. The *Dicentra* plants seem to follow the same pattern.

An inspection of the table shows that if one subtracts the activity in the methylenedioxy groups and the N-methyl group from the total activity in the molecule, one is left with a residual activity approximately twice that in the N-methyl group. An inspection of the structure of protopine shows that it could have originated from two dihydroxyphenylalanine residues plus the carbon atom in the dotted circle. It is tempting to postulate that the residual activity is in this carbon atom, which had its biogenesis in the 'formate' pool of the plant. It has been shown that this 'formate' pool is concerned with biosyntheses involving single carbon atoms[9].

We wish to thank Dr. R. H. F. Manske for the plant material used in these experiments and for providing much useful advice. We also thank the Rockefeller Foundation for financial support for this work.

M. Sribney
S. Kirkwood

Department of Chemistry,
McMaster University,
Hamilton, Ontario.
Oct. 29.

[1] Kirkwood, S., and Marion, L., *J. Amer. Chem. Soc.*, **72**, 2522 (1950).
[2] Kirkwood, S., and Marion, L., *Can. J. Chem.*, **29**, 30 (1951).
[3] Brown, S. A., and Byerrum, R. U., *J. Amer. Chem. Soc.*, **74**, 1523 (1952).
[4] Dubeck, M., and Kirkwood, S., *J. Biol. Chem.* (In the press).
[5] Byerrum, R. U., and Flokstra, J. H., *Fed. Proc.*, **11**, 193 (1952).
[6] Struckmeyer, E., and MacVicar, R., *Bot. Gaz.*, **109**, 237 (1948).
[7] Manske, R. H. F., *Can. J. Res.*, **8**, 592 (1933).
[8] Pregl, F., "Quantitative Organic Microanalysis", 156–160, 4th English edit. (J. and A. Churchill, London, 1945).
[9] Williams, R. J., *et al.*, "The Biochemistry of the B Vitamins", 469–473, 1st edit. (Reinhold, New York, 1950).

Relative Reactivities of the Olefinic and Cyano Links of Acrylonitrile in the Diels–Alder Reaction

THE Diels–Alder reaction, in which a stable six-membered ring is formed by 1,4-addition of an unsaturated linkage to a diene, has wide synthetic application. The role of the olefinic group as a dienophile is well known[1]. More recently, the addition of the cyano group to dienes with the formation of pyridinic products has been reported[2]. Acrylonitrile presents an interesting example in which the groups (C = C) and (C ≡ N), both dienophilic, are present. The present communication reports the results of a study on the reactions of acrylonitrile with butadiene. The relative reactivity of these two links of acrylonitrile in this reaction can be predicted from thermodynamic and kinetic considerations. The free energy changes at 700° K. for the formation of cyano*cyclo*hexene and vinylpyridine are −21 and −14 kcal./mol. respectively. These results are qualitative, since the data for the cyclic products were estimated by the method of group increments[3]; but they show that the two reactions are both thermodynamically feasible in this temperature-range. The ultimate yields are a concern of reaction kinetics. The relative rates of these two reactions, assuming the cyclization to be the rate-controlling step, were calculated from the expression:

$$k_a/k_b = \exp(\,(S_a^{\ddagger} - S_b^{\ddagger})/R - (E_a - E_b)/RT),$$

using the kinetic data of related high-temperature Diels–Alder associations. From a consideration of the activation energies of the reactions of acrolein[4] and cyanogen[5] respectively with butadiene, a minimum value of − 11·9 kcal. was obtained for $(E_a - E_b)$.

The magnitude of $(S_a^{\ddagger} - S_b^{\ddagger})$ for the activated complexes was taken as approximately − 1·1 e.u. from the difference in entropy of 3-cyano*cyclo*hexene and 2-vinyldihydropyridine. Accordingly, at 400° C. in the homogeneous gas phase, it is predicted from these data that the formation of cyano*cyclo*hexene is 5,800 times more rapid than the formation of vinylpyridine.

The experimental study has shown that in the homogeneous reactions at about 400° C., only cyano*cyclo*hexene is found as product of the addition of acrylonitrile to butadiene. This is in accord with the analysis above, that is, very little, if any, vinylpyridine would be formed. In view of the favourable free-energy changes, the reactions were investigated in the presence of a catalyst. With chromium oxide – aluminium oxide as the catalyst system, acrylonitrile reacts by the (C=C) and (C≡N) bonds as predicted from the thermodynamic considerations. Taking yields as a measure of the relative rates of reaction, since both groups are competing for the diene, the reactivity of the (C=C) group is fifteen times greater than the (C≡N) group in the catalysed reactions. A summary of the experimental results is given in the accompanying table.

Experimental reaction conditions				Yields (mol. per cent)	
Catalyst	Time	Temp. (° C.)	Press. (atm.)	Cyano-*cyclo*hexene	Vinyl-pyridine
—	14 hr.	160	1	80	—
—	6 sec.	390	1	77	—
4% Cr_2O_3 on alumina	4 sec.	430	1	28·0	1·8

A detailed account of this work is to be published elsewhere. Acknowledgment is made to the American Cyanamid Company for a fellowship grant in support of this work.

G. J. JANZ
N. E. DUNCAN

Walker Laboratory,
Department of Chemistry,
Rensselaer Polytechnic Institute,
Troy, New York.
Nov. 24.

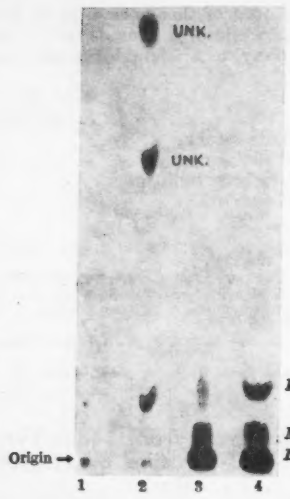
[1] Diels, O., and Alder, K., *Ann.*, **460**, 91 (1928). Alder, K., and Richert, H. F., *Ann.*, **543**, 1 (1939).
[2] Janz, G. J., and Hawkins, P. J., *Nature*, **162**, 28 (1949).
[3] Andersen, J. W., Beyer, G. H., and Watson, K. M., *Nat. Pet. News.*, **36**, *R*376 (1944). Bremner, J. G., and Thomas, G. D., *Trans. Farad. Soc.*, **43**, 779 (1947).
[4] Kistiakowsky, G. B., and Lacher, J. R., *J. Amer. Chem. Soc.*, **58**, 123 (1936).
[5] Hawkins, P. J., and Janz, G. J., *J. Amer. Chem. Soc.*, **74**, 1790 (1952).

Artefacts produced from 3-Iodo-Tyrosine and 3 : 5-Di-iodo-Tyrosine by Heating with Alkali

DURING a study[1] of the hydrolysis of native hog thyroglobulin labelled with iodine-131, by a purified protease isolated from hog thyroid glands, fractions eluted from paper chromatograms of the enzyme fission products were treated with 2*N* sodium hydroxide at 105° for 16 hr. Control aliquots were allowed to stand for the same time at 0°. On application of *n*-butanol extracts of the heated and control samples to paper and development of the chromatograms with *n*-butanol – *n*-pentanol – ammonia[2] as solvent, unexpected radioactive spots of high R_F (at 0·52 and 0·68) were observed with the heated samples. Since the original eluates were found to contain free mono- and di-iodo-tyrosine and thyroxine, the action of alkali on purified samples of the iodo-amino-acids was examined.

Labelled iodo-tyrosines and thyroxine were obtained by the micro-iodination method of Lemmon, Tarpey and Scott[3] from L-tyrosine and 3 : 5-di-iodo-DL-thyronine respectively. The products were separated from unreacted iodide and other impurities by paper chromatography. *n*-Butanol – *n*-pentanol – ammonia was found best for the purification of thyroxine, and *n*-pentanol – propionic acid – water (20 : 3 : 10) for mono- and di-iodo-tyrosine, which were readily separated in this system from each other and from iodide. Incidentally, this acidic solvent system may also be used to separate thyroxine, which has an R_F value of 0·80 compared with 0·28, 0·51 and 0·04 for mono-iodo-tyrosine, di-iodo-tyrosine and iodide respectively on Whatman No. 1 paper.

When labelled thyroxine was heated under the above conditions and the product extracted into butanol, a loss of approximately 10 per cent occurred as measured by iodine-131 activity of the extract, but no artefacts were detected. In the case of di-iodo-tyrosine, however, there was a four- to eight-fold increase in activity of the butanol-soluble fraction compared with the corresponding extract obtained from a control solution allowed to stand at 0°. Moreover, application of the butanol extract of the heated sample to paper and development with butanol – pentanol – ammonia gave radioactive spots at R_F 0·52 and 0·72 corresponding to those detected in the hydrolysates from the enzyme fission products. (On the same chromatogram, carrier mono- and



Radioautogram of chromatogram of butanol extracts, washed with water, of an alkali-treated (2*N* sodium hydroxide, 16 hr.) preparation of iodine-131 labelled 3-iodo- and 3 : 5-di-iodo-L-tyrosine. 1 and 2 : direct extracts of assay (105°) and control (0°). 3 and 4 : extracts of assay and control after adjustment of *p*H to 3·5 with hydrochloric acid. *MIT*, *DIT* : mono- and di-iodo-tyrosine. I⁻ : iodide. UNK : unknown. Solvent : butanol – pentanol – ammonia. Whatman No. 3 paper

di-iodo-tyrosine and thyroxine were made visible by ninhydrin at R_F 0·03, 0·01 and 0·22 respectively.)

The same radioactive artefacts were produced when labelled di-iodo-tyrosine was heated with alkali in the presence of carrier, also from mono-iodo-tyrosine (but to a lesser extent) and from a mixture of labelled mono- and di-iodo-tyrosine. The accompanying radioautogram is of a chromatogram obtained from butanolic extracts of the alkaline solution (before and after adjusting to *p*H 3·5) resulting from an experiment in which a mixture of the iodo-tyrosines was used. An unheated control was similarly extracted and applied.

So far as quantitative studies have been made, it appears that under the above conditions only about 5 per cent of the activity of labelled di-iodo-tyrosine is transferred to the artefact fraction. Thus, in the assay of thyroglobulin for its thyroxine content in which a butanol extract of the hydrolysate is used, the error would be almost negligible ; however, with artificial thyroproteins, owing to the usually higher iodo-tyrosine/thyroxine ratio[4], allowance might have to be made. Friedberg and Reineke have reported recently[5] on the presence of significant amounts of iodine-containing substances other than thyroxine in washed butanol extracts of iodo-casein hydrolysates, but no details are given. It is possible that these substances arise in part from iodo-tyrosines as suggested by the present investigation.

P. G. Stanley

Department of Biochemistry,
University of Melbourne,
Melbourne, N.3.

[1] Gordon, A. W., McQuillan, M., Stanley, P. G., and Trikojus, V. M., Proc. Oxford Isotope Conference, 1951.
[2] Hird, F. J. R., and Trikojus, V. M., *Aust. J. Sci.*, **10**, 185 (1948).
[3] Lemmon, R. M., Tarpey, W., and Scott, K. G., *J. Amer. Chem. Soc.*, **72**, 758 (1950).
[4] Roche J., Michel, R., and Lafon, M., *Biochim. et Biophys. Acta*, **1**, 453 (1947).
[5] Friedberg, W., and Reineke, E. P., *Fed. Proc.*, **11**, 50 (1952).

Latent Carcinogenic Action of Beta-Irradiation on Mouse Epidermis

A single application of a carcinogenic hydrocarbon, in itself insufficient to cause tumours, can bring about a change in mouse skin enabling subsequent applications of the non-carcinogenic substance croton oil to result in the formation of papillomas and carcinomas[1]. It seemed of interest to inquire whether a 'latent' tumour change similar to that produced by the hydrocarbon could be induced in mouse skin by the local application of beta-rays in a single, subcarcinogenic dose.

A total of eighty-six female Swiss mice was used in this first exploratory experiment. As in previous investigations of chemical skin carcinogenesis, the interscapular region was chosen for exposure. Thallium-204 was selected as a source of moderately energetic beta-rays, in order to localize the radiation injury to a relatively small volume of skin. The isotope is produced by neutron bombardment of stable thallium-203 by the reaction ($n\gamma$). Thallium-204 decays to stable lead-204 with the emission of a beta-particle that has a maximum energy of 0·78 MeV. ; its half-life is approximately three years. The thallium was supplied by the Oak Ridge National Laboratory of the U.S. Atomic Energy Commission as thallium nitrate with a specific activity of 0·042 mC./mgm. After purification and repeated precipitation, the thallium nitrate was filtered on paper disks 6 mm. in diameter.

The paper disks were then mounted on 'Lucite' holders and fastened to them with a single layer of Scotch tape. The transparent tape absorbed not more than 10 per cent of the radiation. The dosage rate at the surface of the plaques was calculated, since no appropriate instruments for direct measurements were available. The calculated dose was 870 rep./hr. Two of the plaques were assayed in the Radio-Isotope Control Department of the Oak Ridge National Laboratory through the courtesy of J. H. Gillette, who determined a value of about 800 rep./hr.

For exposure, the animals were placed in tightly fitting cylindrical plastic tubes. The interscapular region of the skin was exposed through a square window in the centre of the tube, into which was fitted the 'Lucite' holder with the radioactive plaque. The animals were held in this position by corks at either end of the tube. The plaque could be manipulated so as to be in direct contact with the skin. All animals were uniformly exposed for one hour, receiving approximately 800 rep. The beta-rays of this energy have a penetration in tissue of 2·5 mm. as a maximum, and the greatest damage, therefore, was done to the epidermis and its appendages. The croton oil was applied twice weekly as a 5 per cent solution in mineral oil (croton oil was obtained from Messrs. Boots, Nottingham, and the mineral oil, 'Superla 34', from the Standard Oil Company of Indiana). Croton oil treatment of the irradiated animals was begun one week following the radiation exposure. It is still continuing to-day with the surviving animals.

The radiation reaction was very mild in the group receiving radiation alone. There was slight erythema with minimal epilation two to three weeks after exposure. The hair grew again, and no skin abnormalities have been observed to date in these animals. In the second group of animals, receiving irradiation followed by croton oil, six animals have developed tumours

Group	No. of animals	Irradiation (rep.)	Croton oil	Animals with tumours	Total No. of tumours	Survivors (8 months)
I	26	800	0	0	0	21
II	30	800	twice weekly	6	13	17
III	30	0	twice weekly	0	0	20

so far, with an average of two tumours per animal. The first tumour was recorded six weeks after painting was begun. There have been no regressions and no malignancies. Some of the tumours were quite large. The average latent period has been 3·5 months. The animals receiving the croton oil alone showed the typical lesions of the skin associated with this treatment. The results are briefly summarized in the accompanying table.

While the total number of animals with tumours may appear small, it should be remembered that the dosages employed in this first experiment were deliberately made small. They were shown to be non-carcinogenic in the irradiated control animals, none of which has developed tumours so far. They were also considerably smaller than those reported to have been carcinogenic by Raper, Henshaw and Snider[2], who with total body beta-irradiation from phosphorus plaques described skin tumours with 3,000–4,500 rep., many of which regressed later on. Glücksmann has stated recently that he has been unable to produce skin tumours in mice with less than 8,000 rep.[3].

This work was supported in part by a research contract from the United States Atomic Energy Commission and in part by a research grant from the National Cancer Institute of the National Institutes of Health, Public Health Service.

PHILIPPE SHUBIK
A. ROBERT GOLDFARB
A. C. RITCHIE

Division of Oncology,
The Chicago Medical School,
Chicago, Illinois.

HERMANN LISCO

Argonne National Laboratory,
Lemont, Illinois.

Feb. 12.

[1] Berenblum, I, and Shubik, P., *Brit. J. Cancer*, **1**, 383 (1947).
[2] Raper, J. R., Henshaw, P. S., and Snider, R. S., chapter 13 in "Biological Effects of External Beta Radiation", edit. R. E. Zirkle (McGraw-Hill Book Co., Inc., 1951).
[3] Glücksmann, A., "Biological Hazards of Atomic Energy", edit. A. Haddow (Clarendon Press, Oxford, 1952).

Occurrence in Plants infected with Tobacco Mosaic Virus of a Crystallizable Antigen devoid of Ribonucleic Acid

PURIFIED preparations of tobacco mosaic virus have often been shown to be heterogeneous, some of the separated fractions being non-infective[1]. The latter are to some extent comparable with the 'soluble antigens' of animal viruses and have a bearing on the study of the mechanism of virus multiplication[2]. The following observations have been made on such fractions.

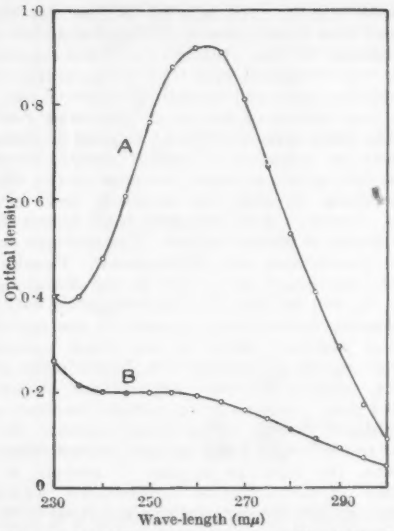
Extracts of the younger leaves of tobacco plants infected two months beforehand were centrifuged for 10–60 min. in a Spinco model *L* ultracentrifuge at 28,000 r.p.m. An aliquot of the supernatant obtained after 60 min. was centrifuged at 40,000 r.p.m. for a further 60 min. Infectivity of the supernatant liquids was compared with that of the initial extract by applying them and several dilutions of the latter to the two halves of leaves of *Nicotiana glutinosa*.

At the same time a sufficient amount of antiserum obtained by injection of tobacco mosaic virus into rabbits was added to equal volumes of the different supernatants, so that the antibody was in slight excess. Controls were prepared from normal serum and extracts of normal plants. The nitrogen content of the precipitates was determined. Results of a typical experiment are given in the accompanying table. It will be seen that centrifugation leads to a considerably more rapid decrease in the number of infective particles than in the total amount of material capable of reacting with the antibody, so that the very slightly infective supernatant obtained at 40,000 r.p.m. contains an important fraction of the total antigen present in the initial extract. Thus, as well as the infective particles with a high sedimentation-rate, the extracts appear to contain a large quantity of non-infective constituents which are immunologically similar, but characterized by a lower sedimentation-rate.

Duration of centrifugation (min.)	Speed (r.p.m.)	Concentration of infective virus particles (arbitrary units)	Protein N antibody + antigen (μgm.)
10	10,000	2,750	1,093
60	28,000	35	308
60	40,000	1	243

On the basis of these preliminary results, one can estimate the sedimentation-rate of the non-infective material remaining in the supernatant after 1 hr. at 40,000 r.p.m. to be at the most 1/30 of that of the infective particles. We attempted to isolate it from the centrifuged extract by the following procedure repeated three times: removal of proteins precipitating at *p*H 4·7; precipitation at *p*H 3·8 of proteins remaining in solution, followed by the taking up into solution of this material at *p*H 7·0. The final precipitate at *p*H 3·8 is exclusively formed of paracrystalline needles identical with those of the virus. The amount of protein isolated was equal to 1/16–1/20 of the infective virus obtained after 60 min. centrifugation at 28,000 r.p.m. This fraction has the following characteristics. It is non-infective. Like tobacco mosaic virus, it is largely precipitated by the antibody of an antiserum obtained by injection of tobacco mosaic virus, but the precipitate is finely granular instead of flocculent. Except in this last character, no other immunological difference has been found between the two substances. As regards the chemical properties, the non-infective protein contains no ribose (negative orcinol test) and no purine or pyrimidine bases (no characteristic ultra-violet absorption of a 10 per cent perchloric acid extract). It does not contain a measurable amount of ribonucleic acid (see graph).

The solution of this protein contains particles visible in the electron microscope and a quarter to an eighth of the length of the tobacco mosaic virus and comparable thickness. These dimensions do not agree with the fact that this protein remains in the supernatant of the initial extract after 60 min. centrifugation at 40,000 r.p.m.; it would thus have a sedimentation-rate much smaller than the one



Absorption spectra of 10 per cent perchloric acid extracts of equal quantities of virus (*A*) and crystallized non-infective material (*B*)

expected for the visible particles. Isolation processes, however, may be accompanied by partial aggregation of initially smaller units. On the whole, this fraction is strikingly similar to the non-infective protein which accompanies the turnip yellow mosaic virus[3]. It is possible that the presence of similar proteins is a general characteristic of virus diseases in plants. A more extensive study of these proteins will be necessary to give us a clue as to their origin and possible significance for virus multiplication.

We are indebted to Mr. F. C. Bawden for the gift of the purified virus employed and seeds of *Nicotiana tabaccum* var. White Burley.

R. Jeener
P. Lemoine

Laboratory of Animal Physiology,
University of Brussels.
Nov. 6.

[1] Bawden, F. C., and Pirie, N. W., *Brit. J. Exp. Path.*, **26**, 294 (1945). Sigurgeirsson, T., and Stanley, W. M., *Phytopath.*, **37**, 26 (1947).
[2] Hoyle, L., *Brit. J. Exp. Path.*, **29**, 390 (1948).
[3] Markham, R., and Smith, K. M., *Parasitology*, **39**, 330 (1949).

Effects of Trichloroacetic Acid on the Extension Growth of Root and Shoot Segments of *Pisum sativum*

It has been established that the sodium or ammonium salts of trichloroacetic acid can be employed for the control of graminaceous weeds in a variety of crops, but little is yet known concerning the physiological effects and the mode of action. Veldstra[1] has shown that, at a concentration of 5×10^{-3} *M*, trichloroacetic acid causes curvature in the split pea test, but doubts whether the operative mechanism is similar to that of recognized growth regulators. On the other hand, Holly, a member of this Unit, observed in East African field trials in 1950 that trichloroacetic acid caused ear deformities in *Dactyloctenium giganteum* and *Panicum maximum* which were very similar to those produced in cereals by 2 : 4 dichlorophenoxyacetic acid. Again, in the laboratory, the morphological effects induced in *Lemna minor* were similar to those caused by the dichlorophenoxyacetic acid.

In the course of a general investigation of the physiological effects of trichloroacetic acid a detailed study has been made of the changes in the extension growth of root and shoot segments of *Pisum sativum* (var. Alaska) induced by this acid either alone or in combination with 2 : 4 dichlorophenoxyacetic acid. The techniques employed are those described by Brown and Sutcliffe[2] for the root segments and Thimann and Bonner[3] for the shoot segments.

The changes in root elongation caused by varying concentrations of trichloroacetic acid are shown in Fig. 1, and it is to be noted that the relationship is of a most unusual type. At exceedingly low concentrations (10^{-11} *M*) there is some inhibition which reaches a maximum at *c.* 10^{-9} *M*. At higher concentrations there is a reversal in trend such that growth is not affected at 10^{-4} *M*, while between 10^{-4} *M* and 3×10^{-3} *M* the rate of elongation is progressively increased. It is not until a concentration of no less than 10^{-2} *M* is reached that extension growth is again inhibited. A possible explanation is that there are three independent actions involved: an inhibitory effect at low doses, which becomes masked by an independent stimulatory effect at intermediate trichloroacetic acid concentrations, and a final inhibition probably associated with gross damage to the tissue.

In contrast to the results for root segments, when similar measurements are made on intact roots, as in the cress-root method devised by Audus[4], there is no evidence of accelerated growth and the reduction occurs at a concentration of about 10^{-2} *M*. The behaviour of the shoot segments is similar to that of the intact roots, except that there is a more progressive reduction in elongation occurring over the range 10^{-4}–10^{-2} *M*.

When shoot and root segments are treated with trichloroacetic acid and 2 : 4 dichlorophenoxyacetic acid alone and in combination, statistical analyses show that there are definite and significant interactions. Because of the complexity of the dose

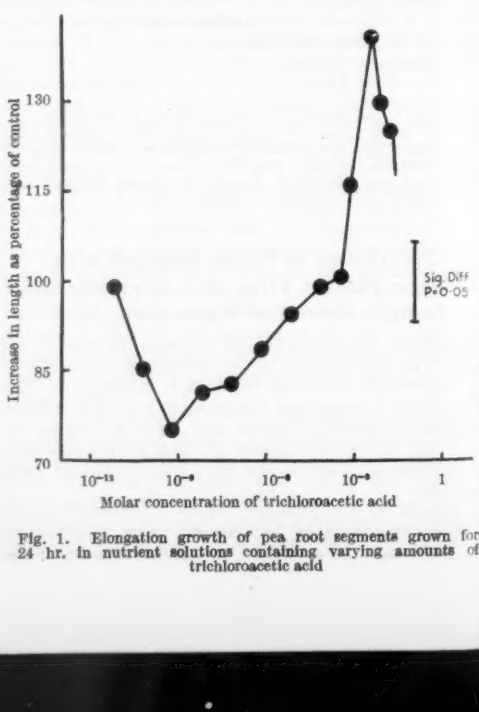


Fig. 1. Elongation growth of pea root segments grown for 24 hr. in nutrient solutions containing varying amounts of trichloroacetic acid

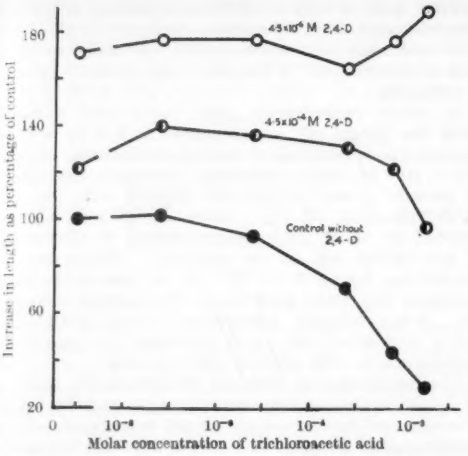


Fig. 2. Elongation growth of pea shoot segments kept for 24 hr. in solutions containing varying amounts of trichloroacetic acid, and 2 : 4 dichlorophenoxyacetic acid

response curves (see Fig. 1) the interpretation of the interactions is complex and a detailed discussion will be published elsewhere, but one aspect is illustrated in Fig. 2. When 2 : 4 dichlorophenoxyacetic acid is added at concentrations of either $4{\cdot}5 \times 10^{-6}$ *M* or $4{\cdot}5 \times 10^{-4}$ *M*, then the normal inhibitory effects of increasing concentrations of trichloroacetic acid are largely eliminated. Indeed it is evident that there are combinations where the increase in extension growth brought about by the growth regulator alone will be accelerated by the addition of trichloroacetic acid at a concentration which by itself would have been markedly inhibitory.

It is suggested that the phytotoxic properties of trichloroacetic acid may be related to the auxin status of the plant and that herbicides consisting of mixtures of trichloroacetic acid and 2 : 4 dichlorophenoxyacetic acid may have definite disadvantages.

GITA SEN
E. K. WOODFORD

Agricultural Research Council
Unit of Experimental Agronomy,
Department of Agriculture,
University of Oxford.

[1] Veldstra, H., *Biochim. et Biophys. Acta*, **1**, 364 (1947).
[2] Brown, R. E., and Sutcliffe, J. F., *J. Exp. Bot.*, **1**, 88 (1950).
[3] Thimann, K. V., and Bonner, W. D., *Amer. J. Bot.*, **36**, 214 (1949).
[4] Audus, L. J., *Plant and Soil*, **3**, 170 (1951).

A Cladoceran from the Plankton as a Possible Indicator for the Presence of the Nile Flood off the Israeli Coast

DURING the examination of the plankton collected in the course of the monthly cruise off the Israeli coast in September 1951 an unusual abundance of a cladoceran, identified as *Podon polyphemoides* (Leuck.), was observed in some of the samples. The organism was found to be present along the coast from Askalon in the south to Athlit in the north, being most abundant at a depth of 10 fathoms, its incidence gradually decreasing towards the 75-fathom depth-line.

The relative scarcity of Cladocera in the marine plankton of this part of the Mediterranean in the preceding and following months suggests that the sudden mass occurrence of *Podon polyphemoides* in the plankton of the coastal waters of Israel at this time of the year is due to a current of water flowing along the coast in a northerly direction. This current is induced by the opening of the dams in the Nile delta a few weeks earlier, thus releasing a powerful flow of fresh water into the sea[1].

A striking correlation has been found to exist between the occurrence of *Podon polyphemoides* and a substantial drop in salinity caused by the Nile flood by the time it reaches the stations where sampling took place along the coast.

The organism is mentioned by previous investigators as occurring occasionally in the plankton of the Suez Canal[2] as well as in the plankton of the eastern and western harbours of Alexandria in the month of March[3]. Steuer[4], however, failed to find *Podon* in the plankton while working in that region, but mentioned in another place the ability of the organism to live both in fresh and salt water[5]. The euryhaline and neritic characteristics of this organism have also been stressed by Ramner[6].

Specimens of this cladoceran were sent to Prof. V. Brehm, who kindly confirmed my identification.

It is to be assumed that the mass occurrence of *Podon polyphemoides* along the Israeli coast during the month of September is connected with the appearance of the Nile flood waters in this region, and may serve as a possible indicator for the detection of the Nile flood in this part of the Mediterranean and the direction followed by the current in its northerly course. Work on this subject is continuing.

B. KOMAROVSKY

Sea Fisheries Research Station,
Haifa, Israel.

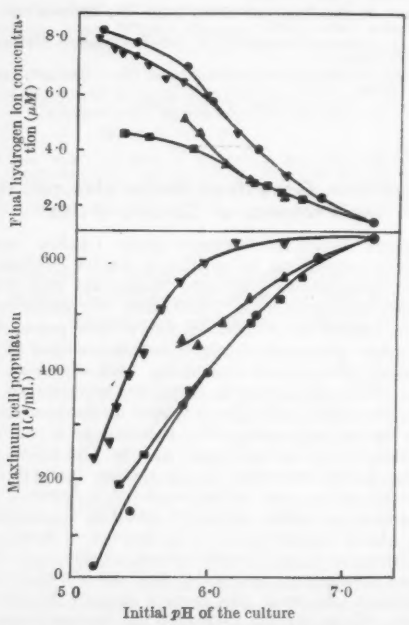
[1] Oren, O. H., Bull. Inst. Océanogr., No. 1017, Monaco (1952).
[2] Macdonald, R., Notes and Memoirs No. 3, Fisheries Research Directorate, Egypt (1933).
[3] Ghazzawi, F. M., Notes and Memoirs No. 31, Hydrobiology and Fisheries, Cairo (1938).
[4] Steuer, A., Notes and Memoirs No. 8, Fisheries Research Directorate, Egypt (1935).
[5] Steuer, A., "Leitfaden der Planktonkunde" (B. G. Teubner, Leipzig and Berlin, 1911).
[6] Ramner, W., *Biol. Centralbl.*, **51**, 619 (1931).

Anaerobic Growth of *Escherichia coli* in the Presence of Certain Acids

CERTAIN coliform bacteria grow readily under anaerobic conditions in synthetic media containing glucose, ammonium sulphate, phosphate and other necessary inorganic ions. The extent of growth, however, is limited to a definite size of cell population even in the presence of excess concentrations of the substrates, the excess remaining unchanged in the media. This phenomenon has been ascribed to the saturation of the hydrogen acceptor mechanisms, and the evidence supporting this contention is strong[1]. The extent of growth depends also on the initial *p*H and the buffer capacity of the media, being less if the initial *p*H or the buffer capacity is lower. The dependence on buffer capacity has led to criticism of the above suggestion[2]. The growth of such cultures is accompanied by production of acid, but their final *p*H depends on the initial, and growth may stop at a higher *p*H than will permit growth in a fresh medium. Thus, though hydrogen ion concentration is undoubtedly a factor, cessation of growth cannot be due solely to its increase.

Since the production of acid per mole of glucose consumed is considerably greater anaerobically than aerobically, it is possible that some of the end-products of the hydrogen acceptor mechanisms are acids and that their production is affected by hydrogen ion concentration. It seemed, therefore, that the effect of adding certain acids to the media would be of interest. The basic medium was buffered with 9·85 gm. per litre potassium dihydrogen citrate adjusted to *p*H 7·2 with sodium hydroxide, and contained sufficient glucose, phosphate and ammonium sulphate to permit the maximum anaerobic growth at this buffer concentration. The organism was *Escherichia coli*, N.C.T.C. 5928, accustomed to the medium and conditions.

In four parallel series of experiments, the effects of additions of lactic, *dl*-malic and succinic acids were compared with those of additions of sulphuric acid. In the diagram, the extents of growth and the hydrogen ion concentrations prevailing as growth ceases are plotted against the initial *p*H. Lactic acid has much the same effect on growth as sulphuric acid, but in all cases the final hydrogen ion concentration is not so great and the difference increases with increase of concentration of lactic acid. At low concentrations the effects of *dl*-malic acid resemble those of lactic acid, but as the concentration increases the results diverge. At concentrations greater than about 6×10^{-3} *M*, *dl*-malic acid compensates for the decrease in initial *p*H and maintains the extent of growth. Parallel results were obtained with medium at an initial *p*H of 6·2. From 0 to 4×10^{-3} *M*, succinic acid maintains the extent of growth despite the lower initial *p*H, but does not affect the final hydrogen ion concentration; above this concentration both the extent of growth and the final hydrogen ion concentration are decreased. Above 8×10^{-3} *M* succinic acid is a more effective inhibitor of growth than sulphuric acid. The three organic acids affect the final hydrogen ion concentration inversely to their own concentration if it lies in a range in which growth is curtailed.



—●—●—, initial *p*H adjusted with sulphuric acid; —■—■—, lactic acid; —▲—▲—, *dl*-malic acid; —▼—▼—, succinic acid

In other experiments with lactic and *dl*-malic acids the initial *p*H was restored to 7·2 by adding appropriate quantities of sodium hydroxide. Up to $9{\cdot}5 \times 10^{-3}$ *M*, either substance decreases the extent of growth down to 500–530 million cells per ml. Thus reduction of the extent of growth can be effected by these acids independently of alterations of the initial *p*H of the medium. Under similar conditions, up to $3{\cdot}5 \times 10^{-3}$ *M* of oxaloacetic acid increases the total growth to 775 million cells per ml. Even without restoration of the initial *p*H, $1{\cdot}9 \times 10^{-3}$ *M* of this acid increases the maximum population to 700 million cells per ml.

The interrelation between inhibition by increase of initial hydrogen ion concentration and by lactic, *dl*-malic and succinic acids would be expected if the undissociated forms of these acids were the inhibitors. The application of this principle could link the capacity of the hydrogen acceptor mechanisms with the buffer capacity of the medium. The three acids studied may be some of the end-products of natural hydrogen acceptor mechanisms; but even if their natural production is not considerable, they would be expected to interfere with a system operating in this manner. It was calculated for experiments in which growth and change of *p*H were small that 1×10^{-3} *M* of undissociated lactic acid was present. If media containing 6×10^{-3} *M* of *dl*-malic acid and 10^{-6} *M* of undissociated lactic acid at a *p*H of 7·2 are inoculated, growth is restricted to 70 million cells per ml. despite the increase in buffer capacity due to the procedure.

G. A. Morrison

University College of Wales,
Aberystwyth.
Nov. 8.

[1] Dagley, Dawes and Morrison, *J. Bact.*, **61**, 433 (1951).
[2] Ravin, *J. Gen. Microbiol.*, **6**, 211 (1952).

Chromosome Numbers in *Holcus mollis*

Investigations into the interspecific relations of *Holcus lanatus* and *H. mollis* have shown that their F_1 hybrids are male-sterile, having only 1–20 per cent of stainable pollen. Chromosome counts have been made on twenty-three of these hybrids with the results given in Table 1.

Table 1

Cross	Chromosome number in F_1 21	22	23	24	25	26	35	40	42	
H. lanatus × *H. mollis*	1	2	3	5	2	2	1	–	–	Frequency
Reciprocal	–	–	2	–	3	–	–	1	1	
	1	2	5	5	5	2	1	1	1	

This unexpected range in chromosome number led to a cytological examination of the parent plants. *H. lanatus* was found to have $2n = 14$, a number which confirms the counts of Avdulov[1] and Litardière[2]. *H. mollis*, however, proved to have $2n = 35$, a new number for this species. Earlier investigators have found two numbers, namely, $2n = 14$ (Stähli[3]) and $2n = 28$ (Löve and Löve[4] and Litardière[2]).

The discovery of pentaploid *H. mollis* prompted a survey of chromosome numbers in both species.

Preliminary results confirm *H. lanatus* as a diploid, while revealing three chromosome numbers in *H. mollis*: tetraploids ($2n = 28$), pentaploids ($2n = 35$) and hexaploids ($2n = 42$) have been found in this species, with frequencies as shown in Table 2.

Table 2

Species	Area of collection	Chromosome number 28	35	42	
Holcus mollis	Aberystwyth	7	30	5	Frequency
	Bayfordbury	–	1	–	
	Durham	1	4	1	
	Exmoor	–	2	–	
	Malvern	–	6	–	
	Neath	–	5	–	
		8	48	6	

These results show that pentaploid *H. mollis* is the most frequent form of this species, and that in some areas at least it co-exists with the tetraploid and hexaploid forms. More extensive investigations are being made to determine the distribution and relative frequencies of the chromosome types in various areas and their relation to each other.

A. R. Beddows
Keith Jones

Welsh Plant Breeding Station,
University College of Wales,
Aberystwyth.
Nov. 7.

[1] Avdulov, N. P., *Bull. App. Bot. Genet.*, etc., Supp. 43 (1931).
[2] de Litardière, *C.R. Acad. Sci., Paris.*, **228** (1949).
[3] Stählin, A., *Wiss. Arch. Landw.*, A, **1**, 330 (1929).
[4] Löve and Löve, *Rit. Landbún.*, B, **3** (1948).

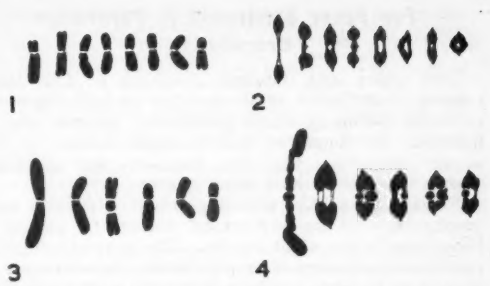
Species Formation in *Trifolium subterraneum*

Subterranean clover (*Trifolium subterraneum*) is indigenous throughout the Mediterranean region. As an introduced species it is a major component of pastures covering some 10 million acres in Australia, and has contributed largely to the development of the Australian sheep industry during the past thirty years.

A recent paper by Yates and Brittan[1] on *T. subterraneum* reports six varieties, collected in Australia, each with 16 chromosomes ($2n = 16$), whereas two varieties, collected in Israel, had only 12 chromosomes ($2n = 12$). I have examined collections from Australia, England, Israel, Malta, Morocco and Portugal. I found, confirming Yates's and Brittan's report, that the easternmost variety, Israel, had 12, and all the others had 16 chromosomes. I also found that the chromosome complement of the Israel variety, in addition to a general increase in size, includes long chromosomes not present in other varieties (see diagrams).

Thus there are two chromosome races of *T. subterraneum* which are not externally different and one of which has so far been found only in Israel. Further, the Israel race has a new basic number $x = 6$, for the tribe Trifolieæ previously reported[2] only with $x = 7$, 8 and 9. Yates and Brittan compared the size and number of the chromosomes of the Israel variety with those of *Vicia sativa* ($2n = 12$) and suggested parallel evolution from a genus outside the Trifolieæ as a possible mode of origin of the new form.

With regard to size, differences in the size of chromosomes in different plants have been shown to be under genotypic control[3,4] and not necessarily indicative of the origin of the species. Further,



Chromosome idiograms from root-tips: (1) $n = 8$, (3) $n = 6$; and first metaphase configurations: (2) $2n = 16$, (4) $2n = 12$, of *T. subterraneum*. Idiograms drawn from Feulgen squash preparations × 3,000. Meiosis from carmine squash preparations × 1,860

Wexelsen[5] has shown differences in chromosome size between different varieties of *Trifolium repens*.

With regard to chromosome number, a more likely suggestion is that the reduction in number is due to rearrangement. If the variety with the reduced chromosome number, $n = 6$, arose in this way from a form with $n = 8$, the changes could have taken place with very little loss of genic material. The greater range in size of the chromosomes of the Israel variety is sufficient to account for the chromosome material from the normal types, even taking into account the general increase in size (see diagram). This rearrangement could result from breakage and reunion of the chromosomes, as suggested by Darlington[4] to account for the different basic numbers in *Fritillaria*. The loss of the centromeres could be explained either by unequal interchanges followed by loss of the very small chromosomes, or by the formation of dicentric chromosomes with extremely short intercentric arms. Such a dicentric would behave as a monocentric chromosome and there would be in effect a fusion of the centromeres.

Such rearrangement has been inferred in *Crepis*[6], where the basic number of the most primitive species, $x = 8$, has been reduced to give species with $x = 7$, 6, 5, 4 and 3. Similarly, in species of *Drosophila* where the primitive species have $n = 6$ and subsequent species $n = 5$, 4 and 3, genetical analysis has confirmed the rearrangement of the chromosomes[7].

The Israel variety of the species has not yet been acclimatized in Australia. Its early-flowering habit would make it of advantage in areas of short seasonal rainfall in Australia. However, its usefulness is limited by its spindly growth habit. All attempts at hybridization with the more leafy types ($2n = 16$) have failed[1]. This inter-sterility and the difference in chromosome number necessitate the recognition of the Israel variety as a cryptic species.

R. D. Brock
(Research Officer, C.S.I.R.O., Australia)
John Innes Horticultural Institution,
Bayfordbury,
Hertford, Herts.
Oct. 31.

[1] Yates, J. J., and Brittan, N. H., *Aust. J. Agric. Res.*, **3**, 300 (1952).
[2] Darlington, C. D., and Janaki Ammal, E. K., "Chromosome Atlas of Cultivated Plants" (London, 1945).
[3] Thomas, P. T., *Nature*, **138**, 402 (1936).
[4] Darlington, C. D., "Recent Advances in Cytology", 77, 559 (2nd edit., London, 1937).
[5] Wexelsen, H., *Univ. Calif. Pub. Agric. Sci.*, **2**, 355 (1928).
[6] Stebbins, G. L., "Variation and Evolution in Plants", 447 (London, 1950).
[7] Dobzhansky, T., "Genetics and the Origin of Species", 244 (3rd edit., New York, 1951).

Fog Fever Syndrome in Parasitic Bronchitis

Two years ago, Hudson, working at this laboratory, described a syndrome that he had observed in adult cattle, of which pulmonary œdema was a feature. He suggested that it might be due to an allergy associated with the small number of lungworms that he noticed were present.

Field studies have shown pulmonary œdema and emphysema to be a common feature of parasitic bronchitis in the adult bovine. The helminthological picture in such cases is very variable. At one extreme there may be large numbers of mature worms present, while at the other only a score or so of microscopic worms may be recovered. Since the development of the worms in the resistant host is often inhibited, their size gives but little indication of the time at which they were picked up.

Clinically, outbreaks of husk in adult cattle make themselves manifest either by a qualitatively uncharacteristic cough, or else, where pulmonary œdema or emphysema or both are present, by a syndrome very closely resembling the condition known as 'fog fever'. This is characterized by dyspnœa and crepitant or squeaking rales. The animal stands with its head stretched out, mouth open and tongue protruded, the ribs are held out and breathing is shallow, rapid and abdominal. The temperature is sometimes high, sometimes normal and may even be subnormal. Generally there is a loud expiratory grunt or groan. Coughing is relatively infrequent.

The occurrence of this syndrome is not confined to adults, and we have observed it in calves after three weeks of exposure to exceptionally heavy natural infection with *Dictyocaulus viviparus*.

We have also been having considerable success in producing the syndrome by the artificial administration of the infective larvæ of *D. viviparus* to young cattle kept under worm-free conditions. We are not able to produce the condition in every animal at will; nor is every case as spectacular as the most acute cases encountered in the field; nor yet is the proportion of deaths any higher than it is in naturally occurring outbreaks. In the twenty-four animals of the present series that have survived the first two months of the initial infection, the syndrome has been observed twelve times. There have been three deaths.

The syndrome, as so far observed, may be recognized as occurring at three stages in our experimental husk infections. Six cases occurred about the time that the initial infection was being spontaneously terminated. Two cases were seen some months after the initial infection had been eliminated, and we believe they may have been associated with the resumption of growth by worms that had been inhibited in their development. Four cases occurred about twelve days after the re-infection of animals that had thrown off the initial infection some time before.

The four circumstances in which the syndrome has been observed, that is, three weeks after first exposure to infection, twelve days after re-infection, about the time the initial infection was being thrown off and when previously inhibited forms may have been resuming their development, are all times at which one might reasonably expect some kind of immune response to be taking place. This would suggest that the condition, the pathology of which resembles that of an allergy, may indeed be related to such a response.

It will be noticed that in the three sets of circumstances in which our artificial fog fevers occur, mature worms will be either few in numbers or absent, while in those cases associated with the spontaneous termination of the infection even immature worms may not be present. This possibility means that the value of post-mortem examination in assessing the cause of naturally occurring cases of fog fever is limited. None the less, the examination of lungs from cases that have been diagnosed as fog fever by clinicians has so far revealed the presence of at least a few lungworms in all six of the lungs that have reached us in good condition.

It would appear from these findings that a proportion of fog fever cases are undoubtedly the consequence of lungworm infestation. The possibility that all fog fevers are associated with this cause cannot be discounted at this stage.

J. F. Michel

Ministry of Agriculture,
Veterinary Laboratory,
Weybridge. Nov. 11.

Transliteration of Cyrillic Script

In *Nature* of March 28, p. 548, the hope is expressed that other countries which use the English alphabet will adopt the Royal Society's scheme for the transliteration of Russian, Bulgarian and Serbian. It is therefore important to point out that the Permanent Committee on Geographical Names for British Official Use (an inter-departmental advisory body) considers the Royal Society's scheme to be unsuited to cartography. Far from letting things take their own course, the Permanent Committee has come to agreement with the United States Board on Geographic Names about the transliteration of Russian and Bulgarian. Serbian is officially written in both the Cyrillic and the Roman alphabets, and to transliterate Serbian geographical names into an English alphabet would produce objectionable variants of their official forms.

In the issue for February 27, 1890 (p. 397), *Nature* offered a system for the transliteration of Russian which was to "be adopted without delay" in the publications of eight leading British learned bodies, including the Royal Society, and which had the support of Russian and American authorities. So far as I am aware, it was not widely put into use, and for a good reason: a system of transliteration, once established in a big library, cannot be changed without great expense, delay and confusion.

The Royal Society has added one more to the dozen or so systems for the transliteration of Slavonic languages already established in British and American use. If agreement in the English-speaking world be possible, it will not be achieved without the co-operation of such bodies as the American Council of Learned Societies; but different English systems for the transliteration of a given foreign alphabet are required for different purposes. A good international system might be better, at least for postal and documentational purposes, than any good national system; but a bad one would be deplorable.

M. Aurousseau
(Secretary)
Permanent Committee on Geographical Names,
c/o Royal Geographical Society,
Kensington Gore, London, S.W.7.

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, May 25—Friday, May 29

TEXTILE INSTITUTE (at Llandudno).—Annual Conference.

Tuesday, May 26

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, 26 Portland Place, London, W.1), at 6 p.m.—Annual General Meeting; at 7 p.m.—Mr. W. A. Goldstein: "The Instrumentation of Pilot and Experimental Scale Plant".

Wednesday, May 27

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Mr. C. A. Moser and Mr. A. Stuart: "An Experimental Study of Quota Sampling".

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Prof. D. Baird and Miss E. M. Scott: "Intelligence and Childbearing".*

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Mr. D. Causley: "High Speed Automatic Counting of Microscopic Particles—The Flying Spot Microscope".

Thursday, May 28

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 4 p.m.—Annual General Meeting; at 5.15 p.m.—Prof. J. A. S. Ritson: Presidential Address.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (at the Royal Institution, 21 Albemarle Street, London, W.1), at 6 p.m.—Sir Harold Hartley, F.R.S.: "The Life and Times of Sir Richard Gregory" (Alexander Pedler Lecture). (Admission by ticket obtainable from the Secretary of the British Association.)

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF PURE MATHEMATICS—The Registrar, The University, Liverpool (May 30).

BIOLOGIST—The Secretary, King's College Hospital Medical School, Denmark Hill, London, S.E.5 (May 30).

BRITISH COKE RESEARCH ASSOCIATION FELLOWSHIP—The Registrar, King's College, Newcastle-upon-Tyne (June 1).

RESEARCH ASSISTANT to work on the fundamental aspects of filariasis—The Secretary, Department of Entomology and Parasitology, Liverpool School of Tropical Medicine, Pembroke Place, Liverpool 3 (June 1).

SENIOR LECTURER IN MATHEMATICS—The Registrar, College of Technology, Birmingham 1 (June 2).

ASSISTANT (with an honours degree in botany) IN THE DEPARTMENT OF BOTANY—The Secretary, The University, Aberdeen (June 3).

JUNIOR FELLOWSHIP IN ELECTRICAL ENGINEERING—The Registrar, The University, Bristol (June 5).

ASSISTANT AGRICULTURAL ECONOMIST—The Registrar, Wye College, Ashford, Kent (June 6).

ASSISTANT LECTURER (Grade 3) or a LECTURER (Grade 2) IN INORGANIC CHEMISTRY—The Registrar, The University, Bristol (June 6).

ESSO STUDENTSHIP IN CHEMICAL ENGINEERING—The Secretary, Department of Chemical Engineering, The University, Tennis Court Road, Cambridge (June 6).

SENIOR LECTURER IN AGRICULTURAL ECONOMY, a SENIOR LECTURER IN AGRICULTURAL ENGINEERING AND FARM MECHANIZATION, a LECTURER IN CROP HUSBANDRY, a RESEARCH FELLOW IN SOIL SCIENCE, a RESEARCH FELLOW IN SOIL CHEMISTRY, and SOIL ANALYSTS (2), at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 6).

LECTURER IN AGRICULTURAL ECONOMICS—The Registrar, The University, Leeds 2 (June 8).

LECTURER IN ORGANIC CHEMISTRY, a LECTURER IN PHYSICAL CHEMISTRY, and a LECTURER IN BIOCHEMISTRY (special experience of biochemistry of micro-organisms desirable)—The Secretary, The University, Aberdeen (June 8).

LECTURER and ASSISTANT LECTURERS (3) IN THE DEPARTMENT OF BIOCHEMISTRY (one of the appointments will entail research in certain physical aspects of biochemistry)—The Secretary, University College, Gower Street, London, W.C.1 (June 8).

SENIOR LECTURER IN CHEMISTRY at the Fourah Bay College (University of Durham), Sierra Leone—The Secretary, Advisory Committee on Colonial Colleges, 15 Victoria Street, London, S.W.1 (June 8).

ASSISTANT LECTURER IN GEOGRAPHY—The Secretary, London School of Economics and Political Science, Houghton Street, Aldwych, London, W.C.2 (June 12).

LECTURER (Grade 1) IN GEOGRAPHY at the University of Ceylon—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (June 12).

RESEARCH OFFICER (with Ph.D. or equivalent standard with special training in microbiological chemistry) TO THE ANIMAL HEALTH RESEARCH LABORATORY, Parkville, Victoria, to carry out investigations in the field of microbiological chemistry—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 201/73 (June 13).

COCHRANE ENTRANCE SCHOLARSHIP IN METALLURGY—The Registrar, King's College, Newcastle-upon-Tyne (June 15).

ENGINEERING AND PHYSICS GRADUATES (with first- or second-class honours degree in engineering, physics or mathematics) to join a group working on servomechanisms and controls—The Secretary, University Engineering Laboratory, Trumpington Street, Cambridge (June 15).

LECTURER (with a first- or second-class honours degree in mechanical engineering) IN THE DEPARTMENT OF APPLIED MECHANICS, and a LECTURER (with a first- or second-class honours degree in mathematics) IN THE DEPARTMENT OF MATHEMATICS—The Director of Studies, Royal Naval College, Greenwich, London, S.E.10 (June 15).

WOOD-WATSON-DONNINI MEMORIAL SCHOLARSHIPS IN METALLURGY OR CHEMISTRY—The Registrar, King's College, Newcastle-upon-Tyne (June 15).

LECTURER IN ANATOMY—The Dean of the Medical College, St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (June 18).

LECTURER IN PSYCHOLOGY—The Secretary, The University, Aberdeen (June 20).

PLANT PHYSIOLOGIST (with good honours degree) at the A.R.C. Unit of Experimental Agronomy, Oxford, to work on fundamental aspects of phytotoxicity and action of herbicides—The Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1 (June 20).

CHIEF LECTURER IN PHYSIOLOGY at the University of Queensland—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (June 22).

COAL SURVEY OFFICER (with good honours degree or equivalent in a science subject, preferably with a sound background in geology and chemistry) in the Central Coalfield of Scotland—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/633 (June 22).

LECTURER IN ELECTRICAL ENGINEERING (with experience in (*a*) heavy electrical engineering, (*b*) high vacuum engineering, or (*c*) radio-isotope applications and nuclear energy)—The Registrar, Queen Mary College, Mile End Road, London, E.1 (June 22).

SENIOR AGRICULTURAL ECONOMIST (to be largely concerned with liaison work between the Provincial Agricultural Economics Service and the National Agricultural Advisory Service)—The Registrar, The University, Leeds 2 (June 22).

LECTURER/SENIOR LECTURER (preferably with research experience in the fields of plant biochemistry, radio-biology, or bacterial chemistry) IN BIOCHEMISTRY at the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (June 27).

CHARLES BROTHERTON SCHOLARSHIP IN THE DEPARTMENT OF COAL GAS AND FUEL INDUSTRIES—The Registrar, The University, Leeds (June 30).

LECTURER IN BIOPHYSICS (with main research interest in the applications of radioactive tracers in biological and medical investigations)—The Secretary to the University, The University, Edinburgh (June 30).

RESEARCH SCHOLAR (with a good honours degree in chemistry)—The Registrar, The University, Reading (June 30).

FOUNDATION CHAIR OF APPLIED PSYCHOLOGY, the FOUNDATION CHAIR OF CIVIL ENGINEERING, the FOUNDATION CHAIR OF MECHANICAL ENGINEERING, and the CHAIR OF ELECTRICAL ENGINEERING, in the New South Wales University of Technology, Sydney—The Agent General for New South Wales, 56–57 Strand, London, W.C.2 (July 1).

CHAIR OF ANATOMY in the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 10).

PHYSICIST or ENGINEER (with experience in the field of nuclear accelerators) to take a responsible part in the operation and technical development of the Nuffield cyclotron—The Registrar, The University, Birmingham 15 (July 15).

ASSISTANT PROFESSOR IN THE DEPARTMENT OF CIVIL ENGINEERING—The Registrar, University of British Columbia, Vancouver, B.C., Canada.

BIOCHEMIST (non-medical)—Dr. J. M. Sherriff, Consultant Pathologist, Hill End Hospital, St. Albans, Herts.

BIOCHEMIST (Senior Grade)—The Physician Superintendent, Crichton Royal Mental Hospital, Dumfries.

HEAD OF THE DEPARTMENT OF MATHEMATICS—The Principal, Borough Polytechnic, Borough Road, London, S.E.1.

LECTURER (Grade B) IN PHYSICS, and a LECTURER IN PHYSIOLOGY—The Clerk to the Governing Body, Battersea Polytechnic, Battersea, London, S.W.11.

MECHANICAL ENGINEER IN THE PUBLIC WORKS DEPARTMENT, Sudan Government—The Sudan Agent in London, Sudan House, Cleveland Row, London, S.W.1, quoting "M/Engineer 1824".

METEOROLOGICAL FORECASTING OFFICER (with good forecasting experience) to the Falkland Islands Dependencies Survey, for service at South Georgia in Sub-Antarctic—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M3B/3325½/NF.

PHYSICIST for work on (*a*) footwear production and wear problems, (*b*) shoe materials and other products used in the industry—The Director, British Boot, Shoe and Allied Trades Research Association, Satra House, Rockingham Road, Kettering, Northants.

PHYSICIST or ELECTRICAL ENGINEER in the Steel Making Division, Sheffield, for research on electric arc furnace problems—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "Arc Furnace".

RESEARCH ASSISTANT IN PHYSICAL or PHYSICAL-ORGANIC CHEMISTRY with particular reference to electrochemical or spectroscopic technique—The Principal, Medway Technical College, Gardiner Street, Gillingham.

SENIOR RESEARCH ASSISTANT (with good honours degree in engineering) IN THE DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING—The Registrar, The University, Nottingham.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Grain Crops: a Summary of Figures of Production and Trade relating to Wheat, Wheat Flour, Maize, Oats, Barley, Rye and Rice. Compiled in the Intelligence Branch of the Commonwealth Economic Committee. Pp. xxiii+144. (London: H.M. Stationery Office, 1953.) 5*s*. net. [173

Library Co-operation in Great Britain. Report of a Survey of the National Central Library and the Regional Library Bureaux. By Robert F. Vollans. Pp. xii+139. (London: National Central Library, 1952.) 5*s*. [193

Science Museum. Handbook of the Collections illustrating Marine Engineering. By H. P. Spratt. Part 2: Descriptive Catalogue. Pp. 160+13 plates. (London: H.M. Stationery Office, 1953.) 7*s*. 6*d*. net. [193

Sotheran's Bibliotheca Chemico-Mathematica: Catalogue of Works in Many Tongues on Exact and Applied Science. Third Supplement. Pp. viii+442. (London: Henry Sotheran, Ltd., 1952.) 42*s*. net. [193

Royal Institute of Chemistry. Lectures, Monographs and Reports 1953, No. 1: The Chemistry and Toxicology of Organic Fluorine and Phosphorus Compounds. By Dr. Bernard C. Saunders. Pp. ii+18. (London: Royal Institute of Chemistry, 1953.) 4*s*. net. [193

Acton Society Trust. Nationalized Industry Series 12: Relations with the Public. Pp. iii+39. (London: Acton Society Trust, 1953.) 2*s*. [193

Ministry of Food. Manual of Nutrition. Third edition. Pp. v+98. (London: H.M. Stationery Office, 1953.) 2*s*. net. [193

University of Cambridge: Department of Engineering. Report of the Acting Head of the Department for the Year 1951–52. Pp. 10. (Cambridge: Department of Engineering, The University, 1953.) [193

Political Activities of Civil Servants. (Cmd. 8783.) Pp. 16. (London: H.M. Stationery Office, 1953.) 6*d*. net. [193

African Education: a Study of Educational Policy and Practice in British Tropical Africa. (Produced on behalf of the Nuffield Foundation and the Colonial Office.) Pp. xii+187. (London: Crown Agents for the Colonies, 1953.) 8*s*. 6*d*. [203

Department of Scientific and Industrial Research. Report for the Year 1951–52. (Cmd. 8773.) Pp. 293. (London: H.M. Stationery Office, 1953.) 8*s*. net. [203

Handbook of Scientific Instruments and Apparatus, 1953, as shown at the 37th Physical Society Exhibition. Pp. xii+262+A.72. (London: Physical Society, 1953.) [233

Year Book of the Textile Institute and Library Catalogue. No. 5, 1952–53. Pp. 142+M.166. (Manchester: Textile Institute, 1953.) 15*s*. [233

Other Countries

Atvinnudeild Háskólans. Rit Fiskideildar 1952, Nr. 1: The Norwegian—Icelandic Herring Tagging Experiments; Report No. 2. By Arni Fridriksson and Olav Aasen. Pp. 54. (Reykjavik: H. F. Leiftur, 1952.) [113

Universities in Adult Education. (Problems in Education, 4.) Pp. 172. (Paris: Unesco; London: H.M. Stationery Office, 1952.) 8*s*. 6*d*. net. [123

Administration Report of the Government Museum, Madras, the National Art Gallery, Madras, the Government Museum, Pudukkottai, and the Connemara Public Library (Exchanges Section), Madras, for 1951–52. Pp. 46+2. (Madras: Government Press, 1952.) [173

Canada: Department of Mines and Technical Surveys, Mines Branch. Memorandum Series No. 123: Electronic Concentration of Ores with the Lapointe Picker Belt. By C. M. Lapointe and R. D. Wilmot. Pp. iv+40. 50 cents. Memorandum Series No. 125: Tin in Canada; Occurrences and Uses. By W. R. McClelland. Pp. iii+17. 25 cents. (Ottawa: Department of Mines and Technical Surveys, 1952.) [173

Geological Society of Australia. News Bulletin, Vol. 1, No. 1, March. Pp. 20. (Melbourne: Prof. E. Sherbon Hills, Chairman, The University, 1953.) 2*s*. [173

Fisheries Research Board of Canada. Bulletin No. 95: A Review of the *Triaenophorus* Problem in Canadian Lakes. By R. B. Miller. Pp. iv+42. (Ottawa: Fisheries Research Board of Canada, 1952.) 45 cents. [173

Canada: Department of Mines and Technical Surveys, Mines Branch, Industrial Minerals Division. Industrial Water Resources of Canada, Water Survey Report No. 2: Ottawa River Drainage Basin, 1947–48. By J. F. J. Thomas. (No. 834.) Pp. 144. (Ottawa: Queen's Printer, 1952.) 75 cents. [173

British Guiana. Report on the Geological Survey Department for the Year 1951. Pp. iv+135. (Georgetown: Geological Survey Department, 1952.) 1 dollar; 4*s*. 2*d*. [173

Smithsonian Miscellaneous Collections. Vol. 117, No. 18: The Lower Eocene Knight Formation of Western Wyoming and its Mammalian Faunas. By C. Lewis Gazin. (Publication 4097.) Pp. vi+82+11 plates. Vol. 121, No. 2: The Birds of the Islands of Taboga, Taboguilla and Uravá, Panamá. By Alexander Wetmore. (Publication 4099.) Pp. ii+32+3 plates. (Washington, D.C.: Smithsonian Institution, 1952.) [173

United States Department of Commerce: Weather Bureau. Research Paper No. 35: The Application of the Hydraulic Analogy to certain Atmospheric Flow Problems. By Morris Tepper. Pp. v+50. 35 cents. Technical Paper No. 21: Normal Weather Charts for the Northern Hemisphere. Pp. ii+74. 1.75 dollars. (Washington, D.C.: Government Printing Office, 1952.) [173

United States Department of Commerce: Weather Bureau. United States Meteorological Yearbook, 1943–1949. Pp. ii+137. (Washington, D.C.: Government Printing Office, 1952.) 60 cents. [173

Administration Report of Museums, Zoos and Government Gardens Department for the Year 1950–1951. Pp. iii+10. (Ernakulam: Government Press, 1952.) [173

Applied Microbiology. Published under the sponsorship of the Society of American Bacteriologists. (Bi-monthly.) Vol. 1, No. 1, January. Pp. 60. (Baltimore, Md.: Williams and Wilkins Company; London: Baillière, Tindall and Cox, Ltd., 1953.) 1.50 dollars; annual subscription, 7.50 dollars; 63*s*. [193

Report of Visitors to University College, Ibadan, January 1952. Pp. 42. (Ibadan: Ibadan University Press, 1952.) [193

Journal of Histochemistry and Cytochemistry: Official Journal of the Histochemical Society. (Bi-monthly.) Vol. 1, No. 1, January. Pp. 86. (Baltimore, Md.: Williams and Wilkins Company; London: Baillière, Tindall and Cox, Ltd., 1953.) 1.50 dollars; annual subscription, 7 dollars; 60*s*. [193

Union Internationale Thérapeutique. III Congreso Internacional de Terapéutica. Comunicaciones. Pp. 218. Ponencias; Potasio, hormonoterapia masiva, radioisótopes. Pp. xvi+452. (Madrid: Union Internationale Thérapeutique, 1952.) [193

British Guiana. Annual Report of the Conservator of Forests for the Year 1951. Pp. 26. (Georgetown: Forest Department, 1952.) [233

Second Annual Report of the National Science Foundation, Fiscal Year 1952. Pp. viii+77. (Washington, D.C.: Government Printing Office, 1953.) 30 cents. [243

Institut Royal des Sciences Naturelles de Belgique. Expédition océanographique belge dans les eaux côtières africaines de l'Atlantique Sud (1948–1949). Résultats scientifiques. Vol. 1, Annexe: Liste des Stations. Par André Capart. Pp. 65+1 plate. Vol. 2, Fasc. 1: Étude physique et chimique du milieu marin. Par Charles Van Goethem. Pp. 151+1 plate. Vol. 3, Fasc. 1: Cumacés, par Louis Fage; Crustacés décapodes, brachyures, par André Capart. Pp. 205+3 plates. Vol. 3, Fasc. 2: Crustacés décapodes, macrures. Par Lipke Bijdeley Holthuis. Pp. 88. Vol. 3, Fasc. 3: Céphalopodes. Par William Adam. Pp. 142+3 plates. Vol. 4, Fasc. 1: Poissons, 1, Généralités; 2, Sélaciens et chimères. Par Max Poll. Pp. 154+13 plates. (Bruxelles: Institut Royal des Sciences Naturelles de Belgique, 1951–1952.) [253

Institut Royal des Sciences Naturelles de Belgique. Exploration hydrobiologique du Lac Tanganyika (1946–1947). Résultats scientifiques. Vol. 1: Avant-propos, par Eugène Leloup; le milieu géographique et géophysique, par André Capart; le milieu biochimique, par Jean Kufferath; le milieu végétal, par Ludo Van Meel; les invertébrés, par Eugène Leloup; les vertébrés, par Max Poll. Pp. vi+168+50 plates. Vol. 2, Fasc. 1: Relevé des stations. Par Eugène Leloup. Pp. 119+15 plates+12 maps. Vol. 2, Fasc. 2: Sondages et carte bathymétrique. Par André Capart. Pp. 16+6 plates+4 maps. Vol. 3, Fasc. 1: Lamellibranches. Par Eugène Leloup. Pp. 153+8 plates. Vol. 3, Fasc. 2: Trematoda, Cestoda and Acanthocephala, by Stephen Prudhoe; Coleoptera carabidæ, par Pierre Basilewsky; Bryozoaires, par Adrianus W. Lacourt; Méduses, par Eugène Leloup; Cyclopides (Crustacés copépodes), par Knut Lindberg. Pp. 97+2 plates. Vol. 3, Fasc. 3: Amphibiens et reptiles, par Gaston de Witte; Hemiptera homoptera, par Victor Lallemond et Henri Synave; Coleoptera lamellicornia, par André Janssens; Crustacés décapodes brachyures, par André Capart. Pp. 67. Vol. 3, Fasc. 4: Gastéropodes. Par Eugène Leloup. Pp. 273+13 plates. (Bruxelles: Institut Royal des Sciences Naturelles de Belgique, 1949–1953.)

Fiskeridirektoratats Skrifter, Serie Havundersokelser. Vol. 9, No. 15: Omplantningene av danske rødspetter (*Pleuronectes platessa*) til Oslofjorden og Skagerak 1934 og 1936. Av Knut Kolstad. Pp. 76. Vol. 10, No. 5: The Densigraph (an Apparatus for Continuous Density Recording of Seawater). By Ernst Føyn. Pp. 10. (Bergen: A/s John Griegs Boktrykkeri, 1953.) [253

Indian Forest Records, New Series. Silviculture, Vol. 7, No. 4: Forests, Catchment Areas and Water Supplies. By E. P. Stebbing. Pp. 247–421. (Delhi: Manager of Publications, 1952.) 3.12 rupees; 6*s*. [253

Institut Royal Météorologique de Belgique. Publications, Série B, No. 3: Sur les équations du mouvement de l'atmosphère intégrées suivant la verticale. Par Dr. Jacques Van Mieghem. Pp. 24. Publications, Série B, No. 5: Températures de coexistence de cristaux de glace et de gouttes salées dans l'atmosphère. Par Dr. L. Dufour et Prof. R. Defay. Pp. 20. Publications, Série B, No. 7: Étude de l'homogénéité des données aérologiques dans une partie du réseau de l'Ouest de l'Europe. Par Dr. L. Malet. Pp. 20. Contributions, No. 6: L'Influence de la force de Coriolis sur les mouvements atmosphériques. Par Paul Dedecker. Pp. 6. (Bruxelles: Institut Royal Météorologique de Belgique, 1952–1953.) [263

Commonwealth of Australia: Department of External Affairs. Australian National Antarctic Research Expedition, Interim Reports 5: Observations of the Aurora Australis, Macquarie Island, May 1950–April 1951. By N. R. Parsons and K. B. Fenton. Pp. iv+338. Interim Reports 6: Hourly Measurements of Ionospheric Characteristics, Macquarie Island, 1951. By Z. R. Jeffrey. Pp. v+155. (Melbourne: Department of External Affairs, 1953.) [303

Catalogues

Vibration Measurement and Waveform Analysis with the Muirhead-Pametrada Wave Analyser. Pp. 24. Valve-Maintained Tuning Forks. (4701–B.) Pp. 4. (Beckenham: Muirhead and Co., Ltd., 1953.)

The Pneumerstat. Pp. 16. (Gloucester: Williams and James (Engineers), Ltd., 1953.)

Shaping the Needs of Industry: How Royal Doulton Works for Industry. Pp. 24. (London: Doulton and Co., Ltd., 1953.)

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £6, payable in advance, postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., Crown House, 143–147 Regent Street, London, W.1
Telephone Number: Regent 3891

All rights reserved. Registered as a newspaper at the General Post Office